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ON THE ESCAPE OF GASES FROM PLANETARY ATMOSPHERES ACCORDING TO THE KINETIC THEORY.

By G. JOHNSTONE STONEY.

PART I.—GENERAL CONSIDERATIONS.

MR. S. R. COOK, in his paper under the above title in the January number of the ASTROPHYSICAL JOURNAL, points out that the present writer, when investigating the escape of gases from atmospheres, does not base his argument upon "the determination by the Kinetic Theory of the relative number of molecules which would have a velocity sufficient to enable them to escape from the Earth or planet."

This is so: and the reason is that no such determination exists except that arrived at in the paper criticised by Mr. Cook, where data drawn from outside the Kinetic Theory are employed to supplement what the Kinetic Theory teaches. These auxiliary data are: (1) that the Moon has not retained an atmosphere; and (2) that the Earth and *Venus* do retain the vapor of water in their atmospheres.

When I first attacked the problem of the escape of gases from atmospheres, which was, I think, in 1867 or 1868, I, like Mr. Cook, hoped that Maxwell's law for the distribution of the speeds of the molecules in gases under normal conditions would render aid; but when I came to consider what the true physical meaning of that law is, and within what limits it holds good, I found that it fails us just where we want its aid, *viz.*, in that outer region of an atmosphere from which alone the entire of the escape of molecules takes place.

My first attempt was to discover a more comprehensive law, of the same kind as Maxwell's, which should give the average proportion of molecules having a given velocity, using the word velocity to include both speed and direction. Such a formula can, without much difficulty, be obtained in a form which covers some states of gas which lie outside the grasp of Maxwell's law. But, after long thought over the subject, I was unable to include under it, or any other formula that I could discover, the unique conditions that prevail near the confines of an atmosphere. All that I could discover, applicable to this case, was some general inferences from general dynamical considerations. These, so far as they need be referred to here, went to show that the breaking down of Maxwell's law as the boundary of an atmosphere is approached is accompanied by an augmentation in the proportion of molecules moving with what may be called outlying speeds, *i. e.*, speeds which deviate much either above or below the speed which Maxwell calls "the velocity of mean square."

On finding that the attempt to base the inquiry upon Maxwell's law could only lead to illusive results, it appeared necessary to cast about for some other way of approaching the problem; and, finally, I adopted the line of argument which is developed in my paper (see this JOURNAL for January 1898, or the *Scientific Transactions of the Royal Dublin Society*, Vol. VI, Part 13).

Maxwell's formula for the distribution of the speeds of molecules in their free paths has reference to what happens in

the case of quiescent gas within an enclosure of which the walls are perfectly elastic, and where the gas is not acted on by any other external force. Let the space within the enclosure be divided up into equal cubes of such a size, ΔV, that each shall contain a sufficient number of molecules, N, for a probability law such as Maxwell's to be apparent in the distribution of the N speeds with which these N molecules are actually moving at any assumed instant of time. This is the point of view from which Maxwell discusses the problem. It is, however, more convenient to secure a sufficient number of molecular speeds in another way. We may, in fact, employ smaller cubes containing fewer molecules, if we compensate for this by extending our survey to all the free paths which these molecules pursue within a sufficient duration, Δt. This change in the point of view is legitimate, since Maxwell's proof of his law applies without alteration to either case; and the change is of advantage, inasmuch as it appears, from investigations which have been made since Maxwell's paper was published, that the smallest volume which we can safely attribute to ΔV, if we adopt Maxwell's point of view, is inconveniently large for some purposes; and since, if we avail ourselves of the new point of view, it becomes possible to gauge by experiment the number of free paths which require to be included in order that the distribution of the speeds of the molecules in them may, in a satisfactory degree, conform to Maxwell's law (see the second part of this paper). If (adopting the new point of view) N be the number of molecules within the space ΔV, and if n be the average number of encounters met with by each molecule in the time Δt, then will Nn be approximately the number of free-paths described within the volume ΔV in the time Δt.

Now Maxwell's law is a probability law, and is, therefore, a limiting law: that is, it is never more than approximately fulfilled; it is widely departed from within the space ΔV if Nn is too small a number, and it more nearly represents the actual state of things the larger the number Nn is, provided that some necessary conditions are complied with. What these conditions

are may be collected from an examination of the successive steps of the proof which Maxwell gives of the law. They are all, as will be seen, fulfilled in a degree which is sufficient for practical purposes, in the air we find about us at the bottom of the atmosphere and in the gases we have to deal with in most laboratory experiments. So far as these conditions need be referred to, they are as follows:

1. It is assumed in the proof of Maxwell's Law that the gas is uniformly distributed throughout the space considered, and that it is isotropic, *i. e.*, the condition of the gas is supposed to be the same in all directions. Now, though gravity increases the density of the lower strata of gas confined within a room, or in the apparatus of a laboratory, it does so in so slight a degree that the first condition is sufficiently fulfilled for practical purposes. This, however, is by no means the case in that outermost stratum of the atmosphere from which the escape of molecules takes place, when we give to the cube ΔV the size which is there necessary to include within it a sufficient number of free paths, and where, besides, the free paths are no longer straight.

2. The gas must also be quiescent or else traveling with uniform speed in some fixed direction. When thus traveling, air is a wind blowing with a velocity that does not vary either in speed or direction; and what Maxwell's law gives when applied to such a wind, is the distribution of the speeds of the velocities that remain after geometrically subtracting the velocity of the wind from the several velocities of the individual molecules.

3. The portion of space ΔV to which we apply Maxwell's law, must be not too narrow in any direction. We have secured compliance with this condition wherever ΔV is of sufficient size to fulfill the other requirements, by selecting a cube as the form of ΔV.

4. The volume ΔV must be large enough and the time Δt long enough, to make the free paths described within the space ΔV in the time Δt, sufficiently numerous to warrant our using

Maxwell's law as representing approximately the actual distribution of speeds among these molecular journeys.

In the present state of our knowledge we are unable to determine by *a priori* considerations what is necessary for the fulfillment of this last condition. We must have recourse to experiment and look out for cases in which there is an appreciable breaking down of Maxwell's law.

The law does not, for example, hold good of the gas within the bulb of a Crookes' radiometer; where, when the instrument is exposed to radiant heat, the molecules thrown back with augmented speed from the darkened side of the vane do not meet with a sufficiency of encounters with other molecules in front of that side of the vane to be able to keep them back in the degree which would equalize the pressure on the front and back of the vane.

Nor does Maxwell's law hold good in ordinary air when we are able to scrutinize effects due to what happens within very small volumes of the air. Thus, if tobacco smoke, confined between two thin slips of glass, is examined with a microscope, the minute flakes of smoke will be seen to dance in a surprisingly lively manner. They are, in fact, being hammered about by coöperating movements of small groups of molecules which now and then form themselves in the air about them, thus betraying to us the deviations from Maxwell's law which must arise whenever we have to deal with swarms of molecules, in which the individual molecules are too few to provide a sufficient number of encounters within the shortest time that our senses can appreciate from changes in the motions of the flakes of smoke. The impacts of single molecules upon those flakes do not, of course, produce appreciable effect, but molecular events succeed one another with such astonishing rapidity — as will appear when we come to deal with details in the second part of this paper — that there is time enough within the hundredth of one second of time for little rushes of small bodies of molecules to have now and then arisen. Such being the case, Maxwell's law cannot assert itself until we contemplate a larger volume or a longer

time or both, until, in fact, so many of such irregularities are embraced in the survey that they are able to balance one another.

What happens here may be illustrated by what takes place in a more familiar case. If 5000 shots were fired at the center of a target from a given distance, out of equally good guns and by equally skilled artillerists, the distribution of the shots round the center of the target would approximately conform to a probability law of the same class as Maxwell's law. But if instead of being directed against one target, the 5000 shots are fired at 1000 targets, five shots at each, the divergence of the effects on the several targets will become conspicuous. On some targets the five shots will be more scattered than on others; on some they will preponderate towards one side; and so on. On scarcely any of them will it be possible to trace even a vestige of the probability law. These are phenomena very much akin to those little rushes in various directions of little swarms of gaseous molecules, which we find now and then occur when we can succeed in scrutinizing what takes place at sufficiently close quarters in ordinary air, and which cause minute bodies suspended in the air to dance. A similar phenomenon, affecting the agitation of the molecules of liquids, is made known to us by the so-called Brownian movements which are familiar to microscopists.

Other instructive instances might be adduced where Maxwell's law ceases to be a safe guide, as, for example, in the distribution of the speeds of the molecules in the stratum of air adjoining a hot surface, and in other cases where special conditions prevail under which a gas may find itself; but we may pass at once to that remarkable exception to Maxwell's law which is forced upon our attention when we endeavor to understand the circumstances under which gases escape from an atmosphere. The entire of the escape takes place from that outer stratum of the atmosphere throughout which the molecules are within practical striking distance of the void space beyond, and out of which they do pass into that void space whenever the circumstances favor their doing so. This stratum of the atmosphere is of great depth, partly on account of the tenuity of the atmosphere in its upper regions, and partly because of the excessively

small ratio which the space occupied by the molecules in those regions holds to the unoccupied space, which greatly lengthens the free paths. The molecules which pursue their long parabolic trajectories within this outermost layer, sometimes making excursions into the void space beyond, find themselves under very different circumstances in different parts of it, and these various circumstances when taken together, as they must be in order that the cubes ΔV may be of sufficient size, constitute a condition of gas complex and altogether remote from that which is essential to the proof of Maxwell's law. Accordingly, throughout this deep outer layer, throughout the neighboring parts of the void space beyond, and throughout such underlying strata of the atmosphere as are sensibly affected by it—in fact throughout the whole of the upper region of the atmosphere—Maxwell's law fails to represent the actual distribution of molecular speeds. At the same time no escape of gas from an atmosphere takes place except what is owing to the events which happen in these very regions. All the numerical results, therefore, which have been reached by employing Maxwell's formula, we must unfortunately expect to be wide of the truth.

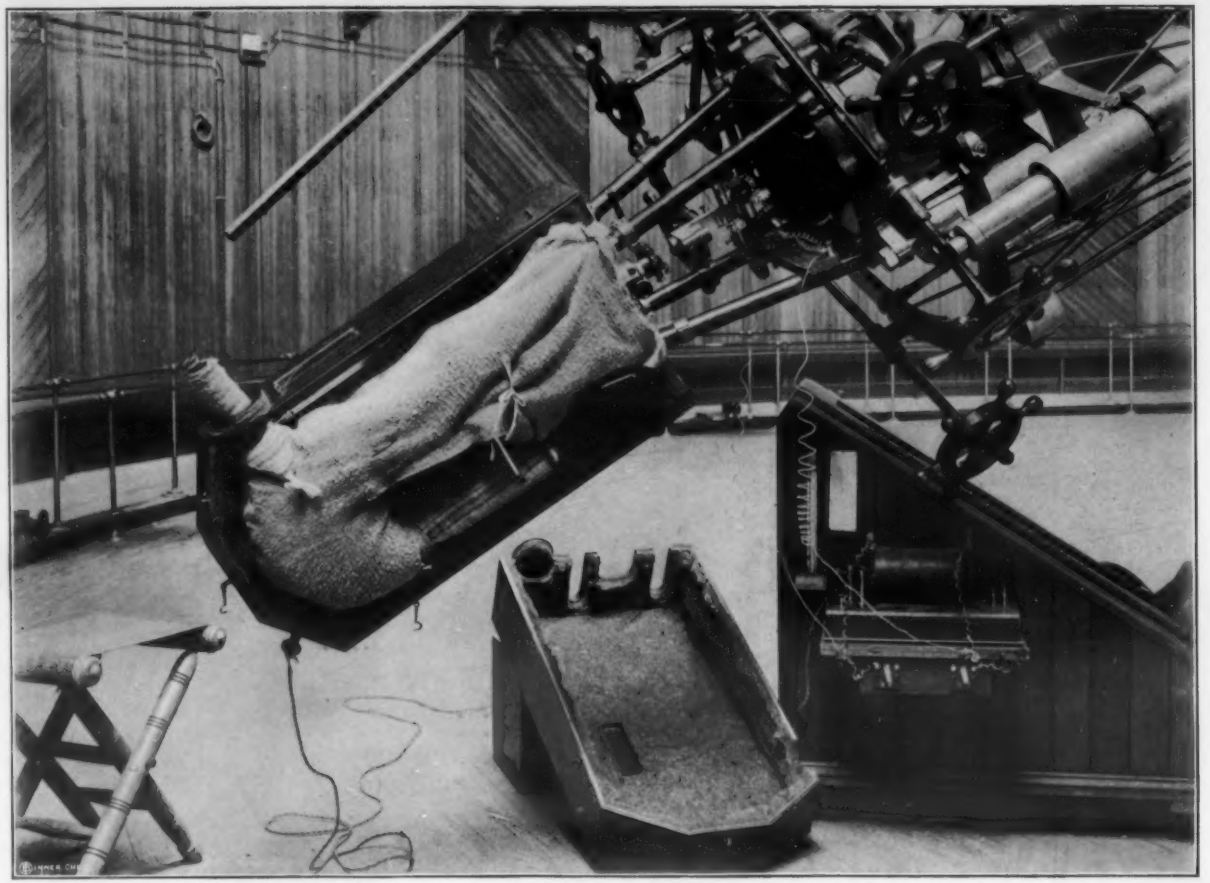
We can, nevertheless, make a certain amount of use of Mr. Cook's results. Maxwell's law may be looked at from another point of view. The physical events with which it deals are these: when an abnormal speed develops itself in any molecule (and we shall find, in the second part of this paper, that such speeds develop themselves several times in each second in every molecule of the air at the bottom of the Earth's atmosphere), then if the crowding of the molecules, the size of the target which each presents to the rest, and the duration of the time Δt, are sufficient to make it probable that, in a sufficiently great majority of cases, the molecules so affected shall subsequently meet with encounters so numerous and of such a kind as will knock the abnormality out of them before the expiration of the time Δt—*in such cases*, and if the gas be gas of uniform density, the outstanding deviations of speed above and below that speed which Maxwell calls the velocity of mean square, will be nearly those which are represented by Maxwell's law.

On the other hand, where, as near the boundary of an atmosphere, an opportunity is afforded to molecules in which an abnormal speed springs up, to place themselves beyond the reach of those subsequent encounters which would tone it down; or in those cases where the volume of ΔV is too small for a sufficiency of such encounters, as happens in the small swarms whose behavior we study in the tobacco-smoke observation; or where from any other cause there is an insufficiency of those encounters which eliminate anomalies: in all cases of any of these kinds the larger deviations of speed will not have been sufficiently toned down for Maxwell's law, but will grow to be more numerous, of larger amount, occasionally more concurrent, and so on, than that law would tolerate.

This is manifested at one extreme by the consequent effect upon suspended flakes of smoke, and at the other extreme it occasions an outflow of molecules from an atmosphere greater than that which would prevail if Maxwell's law held good in respect to the part of the atmosphere which emits these molecules. Thus the numbers obtained by Mr. Cook's method of investigation are of use by furnishing a rate of escape of gas which we know that the real rate of escape must exceed. This in itself is valuable information, and it would be very important information if we had no better way of investigating the problem.

In another respect, not yet taken into account, the constituent gases of an atmosphere are exposed in its upper regions to conditions which further facilitate the escape of gaseous molecules from planets and satellites; namely, owing to interchanges of energy between the internal events which go on within the molecules, and their motions of translation amongst one another. But this branch of the subject is postponed, as it involves the consideration of details which are to form the subject-matter of the second part of this paper, and which it is hoped will throw much light upon several of the matters already partly discussed in the preceding pages.

PLATE V



TEMPERATURE CONTROL OF THE MILLS SPECTROGRAPH

THE TEMPERATURE CONTROL OF THE MILLS SPECTROGRAPH.

By W. W. CAMPBELL.

THE great importance of the temperature factor in spectrographic investigations is recognized by all observers. Variations in the temperature of the apparatus, and especially of the dense prisms, during the progress of an exposure, affect both the definition and the deviation. As previously stated in this JOURNAL (**8**, 140), the Lick Observatory is comparatively free from rapid changes of temperature. It is seldom, after 9 o'clock, that the thermometer readings in the large dome change a half degree Centigrade during exposures of an hour. In order to protect the Mills spectrograph, to a considerable extent, from irregularities in the atmospheric temperature, and from the heat of the observer's breath and body, the entire instrument was covered with two thicknesses of heavy gray woolen blanket, and the prism-box with four thicknesses. A large-scale thermometer was mounted with its bulb inside and near the middle of the prism-box. In a general way, the temperature of the air in the prism-box followed the temperature outside of the blankets ; but the irregularities in the latter were rounded off in the former. The rate of change in the glass prisms themselves was probably even more uniform.

For more than a year past the spectograph has been still further protected against temperature changes by completely inclosing it, save for the slit and guiding telescope, in a box constructed of slowly-conducting material. The arrangement is shown in Plate V. One half of the box is in place on the instrument; and the other half, shown near the floor, fits against and into this by "tongued and grooved" joints. The two halves are held together by five large hooks-and-eyes. The box is of $\frac{7}{10}$ inch Spanish cedar, lined throughout with $\frac{1}{2}$ inch hair felt.

The whole weight, thirty-five pounds, is supported on the upper section of the steel framework. It does not touch the spectrograph at any point. The free spaces between the guiding telescope and the box, and around the steel rods at the upper end, are closed by means of felt pads. A thermometer mounted on the inner surface of the box, and the thermometer in the prism-box can both be read through glass windows, to $\frac{1}{2}\frac{1}{5}^\circ$ Centigrade. A hinged door gives access to the plate-holder, and to the sliding diaphragm which controls the exposures on the brightest comparison lines. The woolen coverings remain in use as before.

German silver wire — B. & S. No. 29, 16½ feet in length in each half of the box — is mounted near the surface of the felt. This wire is readily connected with a 10-volt storage battery, and furnishes the means of controlling a falling temperature.

Care is taken to ventilate the dome and spectrograph, during the day and early evening, so that at dark the readings of the thermometers in the prism-box, in the protecting box, and in the open dome, generally show a range of about 0°.5; and the reading in the dome will usually vary less than 2° during the night. After the adjustments have been made, the spectrograph is inclosed in the blankets and in the box, and allowed to stand from fifteen to thirty minutes, until the temperatures in the prism-box and in the wooden case are partially equalized, before beginning an exposure. The equalizing process is apparent from the fact that, while the dome temperature is usually stationary or slowly falling, the temperature in the wooden case invariably rises to meet that of the prism-box.

The observer notes the reading of the thermometer in the wooden case — shown just above the guiding telescope — and endeavors to keep it constant by means of the electric current, which he controls with a switch near at hand. The temperatures in the case respond slowly to those outside, and rather rapidly to the influence of the current. Some irregularities necessarily exist in these temperatures; but their effects are rounded off before reaching the prism-box, and are scarcely appreciable.

The efficiency of the apparatus is illustrated by the following extract from the observing books, on a night when the temperature changes in the dome were unusually irregular. The readings were made at the beginning and ending of the exposures:

Plate number	Limits of exposure time. Mt. Hamilton M.T. 1899, Aug. 29	Temp. in dome	Temp. in wooden box	Temp. in prism-box
1433 A	$8^h\ 28^m$	+17°.9 C.	+18°.4 C.	+18°.84 C.
	10 02		18.9	18.80
1434 B	10 24	18.5	18.8	18.78
	11 00		19.0	18.80
1435 C	11 31		19.0	18.80
	13 07	17.2	19.0	18.80
1436 D	13 38		18.7	18.70
	15 15		18.8	18.70
1437 A	15 32		18.8	18.74
	16 09	19.0	19.0	18.74

An automatic control of the current could be arranged, but the need of it has not been seriously felt. Such a control should be independent of the variable component of gravity in the different positions of the instrument.

No provision has been made for reducing a rising temperature which sometimes occurs. It is possible that a spray of some volatile liquid within the wooden case would be efficient and practicable.

The use of this box and the controlling current has contributed appreciably to the accuracy of our line-of-sight determinations.

Acknowledgments are due to Mr. Wright for many of the ideas utilized; and to Professor Cory, of this University, who verified the computations for the thermal system and supplied the constants of the wire.

LICK OBSERVATORY,
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March 1900.

ON THE ORIGIN OF CERTAIN UNKNOWN LINES IN THE SPECTRA OF STARS OF THE *β CRUCIS* TYPE, AND ON THE SPECTRUM OF SILICON.[1]

By JOSEPH LUNT.

IN a recent paper "On the presence of Oxygen in the Atmospheres of certain Fixed Stars,"[2] Dr. Gill calls attention to three unknown lines in the spectra of *β Crucis*, *ε Canis Majoris*, and stars of their type, *viz.*, wave-lengths 4552.79, 4567.09, 4574.68.

Mr. McClean had previously also recorded these lines in his measures of the spectrum of *β Crucis*[3] as wave-lengths 4552.6, 4567.5, 4574.5, but beyond pointing out the approximate coincidence of the first of these with lines due to barium or titanium, he assigns no origin to them.

Sir Norman Lockyer frequently records them as unknown lines. In his recent paper "On the appearance of the Clèveite and other New Gas Lines in the Hottest Stars" (June 1897),[4] he records all three lines as unknown. The first occurs in a map of the spectrum ot *Bellatrix* as a line in a probably new series found by Dr. W. J. S. Lockyer. The second and third lines, given as 4566.8 and 4574.8, occur in a Table of Lines which Sir Norman regards as belonging, with high probability, to gaseous substances which have yet to be discovered.

It will be noticed that the connection existing between the three lines is not there recognized.

In none of the Tables of Wave-Lengths available for reference at the Cape could any satisfactory clue be obtained as to the origin of the lines.

During some experiments made with a view to securing the best elementary line spectrum of oxygen as a comparison

[1] *Proc. R. Soc.*, **66**, 44–50, December 1899.

[2] *Proc. R. Soc.*, **65**, 205; this JOURNAL, **10**, 272, 1899.

[3] *Spectra of Southern Stars* (Stanford, 1898), p. 13.

[4] *Proc. R. Soc.*, **62**, 60.

spectrum for stars of the *β Crucis* type, I found that a tube of carbon dioxide gave the best results, being freer from impurities, and giving stronger oxygen lines than any of the oxygen tubes at my disposal. By the use of a jar and air gap in the secondary circuit of the coil the gas was dissociated, and gave the spectra of carbon and oxygen. During use, the carbon dioxide tubes became more vacuous, and, with a view to obtaining a brighter discharge and shorter exposure, I passed the induced current from an 18-inch Apps' coil, using four large jars and an air gap.

Whilst using these electrical conditions, I happened to expose an argon tube marked 2 mm (pressure), and on developing the photograph was much surprised to find that it, too, gave the well-recognized lines of oxygen. Stronger than these I at once noticed two lines at the green end of the spectrum, which recalled the lines in *β Crucis*, which were unknown terrestrially, whilst the expected argon spectrum was almost entirely absent.

On comparing the negative, film to film, with one of *β Crucis*, and allowing for the difference of temperature conditions under which the two negatives were taken, the identity of the three unknown lines in *β Crucis* with three lines on the argon negative was at once apparent, and a subsequent photograph of the spectrum of *ε Canis Majoris*, in which the argon tube was used, as stated, as a comparison spectrum, established their absolute identity both as regards position and relative intensity.

It was, therefore, evident that a terrestrial source of the three unknown lines had been discovered, and with the behavior of the carbon dioxide tube fresh in mind, and the replacement of the argon spectrum by unknown lines and those of oxygen by use of a highly disruptive spark, it is not surprising that an obvious startling explanation as to the nature of the element thus found terrestrially should have suggested itself.

It was at first assumed, erroneously as it afterwards proved, that the origin of the unknown lines lay in the gaseous contents of the argon tube. Four argon tubes in succession gave precisely the same results, *viz.*, the argon spectrum with an ordinary

discharge and the unknown lines and oxygen, together with the disappearance of the argon spectrum, as a result of using the jars and air gap. On communicating these results to Dr. Gill, he at once interested himself in the matter, and gave every facility for a further prosecution of the inquiry. He remembered that Professor Ramsay had furnished him with a specimen tube of pure argon, and this tube had not been examined. On trying this tube under the same conditions as the others, it was found to give the argon spectrum under all conditions. Neither the unknown lines nor oxygen made their appearance, even when the most intense disruptive spark available was employed.

The first four tubes had aluminium electrodes, whilst Professor Ramsay's tube had platinum electrodes, and was more vacuous and much shorter.

A pair of aluminium electrodes was then taken from a vacuum tube, and a spark between the metal terminals in air was next examined, with the result that the unknown lines were not found. A line appeared very approximately in the same position as the strongest of the three lines, but this was only one of the numerous air lines, and was due to nitrogen (4552.6 Neovius). Therefore, the electrodes of the argon tubes did not account for the unknown lines.

On a further examination of the negatives, the H and K lines of calcium were recognized in the spectra of the argon tubes subjected to the highly disruptive spark, pointing to the fact that the lime of the glass was being volatilized.

This fact alone might account for the presence of the oxygen lines in the spectra, and the materials of the glass were then suspected as being the origin of the lines under consideration.

A tube of pure helium, kindly furnished to Dr. Gill by Professor Ramsay, was next examined, and, with much surprise, this was found also to behave exactly as the first argon tubes had done.

With an ordinary discharge it gave the pure helium spectrum, but with the highly disruptive discharge the helium spectrum *vanished entirely*, and was replaced by the unknown lines and the

spectrum of oxygen. The helium spectrum could be obtained at will by reverting to the ordinary discharge.

This helium tube had platinum electrodes, and these last observations finally banished any idea that the gaseous contents of the tubes or the metallic electrodes could be the origin of the substance searched for, and the conclusion that the glass of the tubes contained the substance sought was now irresistible. Yet in some of the spectra from the helium tube, the H and K lines of calcium were absent when those of oxygen were present, showing that the lime of the glass did not necessarily account for the presence of oxygen.

After various fruitless experiments, sparks were taken between the platinum terminals of a broken up vacuum tube on which still adhered some of the blue fusible glass, commonly used in sealing in platinum wire in glass. The spectrum of this spark in air showed the unknown lines.

Beads of glass made from ordinary soda glass tubing, were then fused on platinum wires, and the spark from these was examined. The unknown lines again appeared. The substance sought was now strongly suspected to be the element silicon. The siliceous diatomaceous earth "kieselguhr" was next used as the most convenient source of silica, and beads of sodium silicate were made by fusing this material with sodium carbonate on platinum wire. The result of the examination of the spark was that the unknown lines were again found. The next step was to replace the kieselguhr by pure rock crystal obtained from the South African Museum by Dr. Gill. Sodium silicate made from the pure rock crystal also furnished the unknown lines, whilst the sodium carbonate alone failed to give them.

These experiments left little room for doubt that the element sought was silicon. Nevertheless, it was very desirable to confirm the result in another way, by examining the spectrum of a gaseous siliceous compound.

Platinum wires were sealed into the ends of a piece of wide glass tubing, $\frac{5}{8}$ inch internal diameter, the ends of the wires leaving a gap of only $\frac{5}{8}$ inch for the passage of the spark. The tube

was also furnished with an inlet and outlet tube for the gas. No capillary tube was used in order to avoid the hot spark coming into direct contact with glass. The tube was then filled with silicon tetrafluoride, and after the gas had been passing for some time, it was sealed off at atmospheric pressure.

An ordinary discharge passed through the gas without jars or air gap gave a banded spectrum of the compound itself.

The disruptive discharge obtained by using four jars and an air gap, at once gave the unknown lines, which were thus proved to be undoubtedly due to silicon.

This silicon spectrum was not accompanied by that of oxygen, thus proving that it could not be due to any dissociation of the silica of the glass, and that in this case, the gaseous contents of the tube and not the tube itself furnished the lines under consideration.

Sir Norman Lockyer's papers were then consulted for any reference to the presence of silicon in stars, and it is necessary to refer in some detail to his observations. It is evident that he has used similar powerful disruptive discharges with vacuum tubes, and obtained partial decomposition of the glass, for he says:[1] "The use of the spark with large jars in vacuum tubes results in the partial fusion of the glass, and the appearance of lines which have been traced to silicium."

Unfortunately he does not give the wave-lengths of the lines thus traced to silicon, and from his statement alone, one would surmise that the origin of the three lines was recognized by Lockyer.

There is evidence, however, *in the same paper* that he cannot have traced the lines in question to silicon notwithstanding the above statement, because, as previously pointed out, Sir Norman regards two of the lines as belonging to gases yet undiscovered, and includes them in a table of wave-lengths of lines due to unknown *gases*.

The other line he also includes as an unknown line in *Bellatrix*, and Dr. W. J. S. Lockyer places this as a member of a probably rhythmic series due to an unknown substance.

[1] *Proc. R. Soc.*, **62**, 65, 1897.

It is a curious fact that Hartley and Adeney, and Eder and Valenta, who alone give us any extended list of lines due to silicon, appear not to have examined the spectrum of this element in the region of the three lines here considered. Their published wave-lengths show only lines in the extreme ultra-violet, and the majority of them are quite outside the region which can be examined by the McClean star spectroscope.

Watts's *Index of Spectra* (Appendix E, p. 21) records a line at 4566 (Salet), but no lines appear corresponding to 4552.79 and 4574.68.

Sir Norman Lockyer[1] regards two lines at 4128.6 and 4131.4 as the most conspicuous enhanced lines of silicon; indeed these two lines are the only silicon lines he labels *Si* in his published photographs. Eder and Valenta give 4131.5 and 4126.5 as the least refrangible on their list, and although there is a rather excessive discrepancy in the wave-lengths of one of the lines, they are probably the same pair of lines. They are shown in Lockyer's photographs of the spectra of *α Cygni* and *Sirius*[2] and also of *α Cygni* and *Rigel*.[3]

It is a remarkable fact that these three stars, which may be considered as amongst the best examples of silicon stars in the light of the spectrum of silicon hitherto known, *do not show* the three silicon lines which are so prominent in *β Crucis*, *ε Canis Majoris*, etc. Scheiner has measured the spectra of all three stars[4] in this region, but does not record the lines in his table of wave-lengths.

Their absence from the spectra of these stars (as well as the presence of Lockyer's enhanced silicon lines) is fully confirmed by photographs taken here with the special object of searching for the new silicon lines in the best known silicon stars.

This can be readily understood in the light of the experiments with the tube of silicon tetrafluoride.

With the highest disruptive spark, Lockyer's silicon lines 4128.6 and 4131.4 are much enhanced as compared with the

[1] *Proc. R. Soc.*, **61**, 443, 1897.

[2] *Proc. R. Soc.*, **65**, 191.

[3] *Phil. Trans.*, A (1893), plate 2.

[4] SCHEINER'S *Astronomical Spectroscopy*.

lines 4552.79, 4567.09, 4574.68, and it was found possible by suitable exposure to obtain the two enhanced lines without the presence of the other three lines becoming evident.

The latter lines would be much more rapidly obliterated in the absorption spectra of stars, than in the bright line spectrum from the tube, and therefore their absence from certain stars in which the enhanced lines are strong need not occasion much surprise.

In other stars, however, all five lines are present. Lockyer has recorded them in *Bellatrix* and their presence has been confirmed by photographs of the spectrum of this star taken here.

Mr. McClean has measured all five lines in *β Crucis*, where Lockyer's enhanced silicon lines are certainly not so conspicuous as the lines 4552.79 and 4567.09.

The same may be said of *ε Canis Majoris*, in which star the new silicon lines are very prominent, whilst the enhanced lines are very faint.

In the silicon spectrum from the argon and helium vacuum tubes, the enhanced lines noted by Lockyer are by no means so prominent as they are in the silicon spectrum, obtained from silicon tetrafluoride with the intense disruptive spark. It is evident, therefore, that great variations in the relative intensities of the silicon lines occur in stellar spectra, and that such variations can be produced to a certain extent in the laboratory, and these require further investigation.

The behavior of the silicon lines will give us valuable data for the elucidation of the problem of relative stellar temperatures.

It is clear that if we regard, with Lockyer, the lines 4128.6 and 4131.4 to be the enhanced lines of silicon, and their presence, enhanced, to be a criterion of a higher temperature than occurs in stars where these lines are *not* enhanced, it must follow that such stars as *α Cygni*, *Rigel*, and *Sirius* are hotter than *Bellatrix*, *β Crucis*, and *ε Canis Majoris*. Whereas Lockyer[1] in his most recent paper "On the Chemical Classification of the Stars"

[1] *Proc. R. Soc.*, **65**, 189.

(April 1899), regards the so-called "Crucian" stars as at a higher temperature than the "Rigelian" and "Cygnian," and indeed he regards *Bellatrix* "as a type of the hottest stars, exception being made of *ζ Puppis*."

Of the other lines recorded by Eder and Valenta[1] as due to silicon, 3905.4, 3862.5, and 3855.7 are present both in the spectra of the dissociated glass and in the high temperature spectrum of silicon obtained from the silicon tetrafluoride tube.

They are enhanced lines in the latter case, occurring together with Lockyer's enhanced lines in the absence of the three new silicon lines, but they lie outside the region measured by Scheiner in *α Cygni*, *Sirius* and *Rigel*.

In the Harvard "Spectra of Bright Stars"[2] the two latter lines are, however, specially noted in *Rigel* as 3863.2 and 3856.2 as "conspicuously strong in the ultra-violet," whilst all three are recorded (3905.6, 3863.2, 3856.2) in stars of Groups VI to VIII (Harvard), comprising *α Cygni*, *Sirius*, and *Rigel*. They would thus appear in these stars to accompany the enhanced silicon lines, especially noted by Lockyer, *viz.*, 4128.6 and 4131.4.

The lines 3834.4 and 3836.7 recorded by Eder and Valenta are not present in any of the photographs of silicon spectra, and may possibly be due to impurities.

The lines 3795.9 and 3791.1 recorded by Eder and Valenta are present in all the silicon photographs, but do not become enhanced at high temperatures. There is, however, a third line, approximately λ 3807, not recorded by them, but which appears in all the photographs of silicon spectra. It is stronger than 3795.9 and 3791.1, and does not become enhanced with high temperature. All three lines accompany the three new silicon lines in *ε Canis Majoris*.

[1] WATTS, *Index of Spectra*.

[2] *Harvard Annals*, **28**, Part I, Table 7, p. 23.

ON THE MAGNITUDES OF 919 FIXED STARS DETERMINED FROM SEQUENCES OBSERVED BY SIR JOHN HERSCHEL DURING THE YEARS 1835 TO 1838.

II.

By W. DOBERCK.

TABLE III.

Catalogue of mean magnitudes of stars observed by Herschel, and reduced by aid of the *Uranometria Argentina*.

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
1	α *Andromedae*....	0 1.9	+28 24	2.14	1	—	—	—	—	—
2	κ^1 *Sculptoris*.....	0 3.0	−28 41	5.82	1	5.0	5.5	—	—	—
3	ε *Phoenicis*.....	0 3.1	−46 26	3.89	3	4.1	3.8	4.0	4.0	3.96
4	κ^2 *Sculptoris*.....	0 5.2	−28 30	5.82	1	4.5	5.4	—	—	—
5	γ *Pegasi*.....	0 6.8	+24 29	2.78	1	—	—	—	—	—
6	ζ *Toucani*.....	0 13.5	−65 37	4.34	3	4.5	4.1	4.5	4.1	4.31
7	ι *Sculptoris*.....	0 15.2	−29 40	5.84	1	6.4	5.3	5.6	—	—
8	ξ *Toucani*.....	0 18.5	−72 47	4.53	1	—	4.5	—	4.1	cum.
9	β *Hydri*.....	0 19.1	−77 57	2.90	11	3.1	2.7	2.9	3.2	—
10	κ *Phoenicis*.....	0 20.0	−44 22	4.06	3	4.1	3.9	4.1	4.0	4.03
11	α *Phoenicis*.....	0 20.1	−42 59	2.54	5	2.3	2.4	2.5	2.7	2.49
12	*Lac. 106*.....	0 24.1	−24 29	5.57	1	5.4	5.2	—	—	—
13	λ^1 *Phoenicis*.....	0 25.4	−49 30	4.78	2	5.0	4.6	5.1	4.8	4.86
14	β *Toucani*.....	0 25.8	−63 39	3.65	4	3.8	3.7	3.9	4.0	—
15	*Lac. 125*.....	0 27.5	−30 15	5.83	1	6.4	5.8	6.0	—	6.01
16	μ *Phoenicis*.....	0 35.4	−46 46	4.95	2	5.0	4.7	4.9	4.9	4.89
17	ρ *Toucani*.....	0 37.1	−66 9	5.33	1	5.8	5.7	5.8	—	—
18	β *Ceti*.....	0 37.3	−18 40	2.22	6	—	2.3	—	—	2.26
19	η *Phœnicis*.....	0 37.7	−58 9	4.34	2	5.4	4.5	4.7	—	var.?
20	ϕ^1 *Ceti*.....	0 37.9	−11 17	4.88	1	—	5.1	—	—	—
21	*Lac. 193*.....	0 38.6	−22 42	5.74	1	5.4	5.3	—	—	—
22	*18 Ceti*.....	0 39.2	−13 33	5.70	1	—	6.3	—	—	—
23	*Lac. 203*.....	0 40.0	−23 12	5.78	1	6.4	5.8	—	—	—
24	*Ll. 1349*.....	0 43.2	−14 14	5.90	1	—	5.9	—	—	—
25	ϕ^2 *Ceti*.....	0 43.9	−11 19	5.66	1	—	5.5	—	—	—
26	ρ *Phoenicis*.....	0 45.0	−51 40	5.19	1	4.5	5.6	5.4	—	—
27	ϕ^3 *Ceti*.....	0 49.7	−11 57	5.88	1	—	5.7	—	—	—
28	ϕ^4 *Ceti*.....	0 52.5	−12 3	5.88	1	—	5.9	—	—	—
29	α *Sculptoris*.....	0 52.6	−30 2	4.02	1	4.1	4.2	4.7	—	—
30	*27 Ceti*.....	0 59.3	−10 39	5.79	1	—	6.5	—	—	—
31	*28 Ceti*.....	0 59.8	−10 31	5.88	1	—	5.7	—	—	—
32	β *Phoenicis*.....	1 0.5	−47 23	3.43	3	3.1	3.3	3.4	3.4	3.33
33	*30 Ceti*.....	1 1.5	−10 27	5.89	1	—	5.8	—	—	—
34	η *Ceti*.....	1 2.3	−10 51	3.25	3	—	3.5	—	—	—
35	ζ *Phoenicis*.....	1 3.1	−55 55	3.94	2	4.1	4.2	4.2	—	4.11

TABLE III—*Continued.*

No.	Name.	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
36	*37 Ceti*	1 8.1	— 8 36	5.15	1	—	5.3	—	—	—
37	*κ Toucani*	1 11.5	—69 32	5.11	1	5.0	5.1	5.2	4.8	5.04
38	*Polaris*	1 13.0	+88 39	2.18	2	—	—	—	—	—
39	*θ Ceti*	1 17.8	— 8 50	3.60	2	—	3.2	—	—	—
40	*46 Ceti*	1 19.5	—15 15	5.35	2	—	5.1	—	—	—
41	*γ Phoenicis*	1 22.9	—43 57	3.51	3	3.1	3.4	3.4	3.5	3.38
42	*48 Ceti*	1 23.6	—22 17	5.22	1	5.4	5.3	—	—	—
43	*Br. 214*	1 25.7	—30 38	5.87	1	6.4	6.8	—	—	—
44	*Br. 215*	1 25.9	—30 56	5.62	1	6.4	6.0	6.1	—	—
45	*δ Phoenicis*	1 26.0	—49 43	3.95	3	4.1	4.0	4.1	4.0	4.03
46	*Ll. 2848*	1 27.4	— 7 40	5.91	1	—	5.9	—	—	—
47	*τ Sculptoris*	1 30.4	—30 33	5.45	1	5.4	5.9	6.2	—	var.?
48	*α Eridani*	1 33.0	—57 52	1.07	15	1.0	1.0	1.0	1.1	1.03
49	*Ll. 3137*	1 35.6	—11 56	5.92	1	—	5.8	—	—	—
50	*τ Ceti*	1 38.3	—16 36	3.45	2	—	3.4	—	—	—
51	*ε Sculptoris*	1 39.8	—25 41	5.41	1	5.0	5.4	—	—	—
52	*χ Ceti*	1 43.4	—11 18	4.96	3	—	4.8	—	—	—
53	*ξ Ceti*	1 45.3	—10 57	4.45	1	—	3.5	—	—	—
54	*Ll. 3479*	1 46.9	—17 33	5.80	1	—	5.8	—	—	—
55	*β Arietis*	1 47.7	+20 11	3.07	1	—	—	—	—	—
56	*ψ Phoenicis*	1 48.6	—46 55	4.90	1	5.0	4.8	4.3	5.0	4.88[1]
57	*τ² Hydri*	1 49.0	—80 48	5.07[2]	1	6.4	6.1	6.5	—	—
58	*φ Phoenicis*	1 49.2	—43 7	4.73	1	5.4	5.5	5.3	5.0	—
59	*56 Ceti*	1 50.8	—23 8	5.31	2	5.8	5.0	—	—	—
60	*χ Eridani*	1 51.1	—52 14	3.73	3	4.1	3.9	3.7	3.8	3.85
61	*π² Hydri*	1 51.8	—68 16	5.10	2	4.5	4.9	4.9	4.9	4.86
62	*Lac. 585*	1 52.2	—48 0	4.93	1	5.4	5.1	4.9	5.1	5.09
63	*57 Ceti*	1 53.9	—21 26	5.60	1	6.4	5.7	—	—	—
64	*υ Ceti*	1 54.1	—21 41	3.95	2	3.8	3.9	—	—	—
65	*α Hydri*	1 54.8	—62 11	3.06	8	3.1	2.9	3.0	2.8	2.97
66	*α Piscium*	1 55.6	+ 2 10	3.53	2	—	3.8	—	—	—
67	*π Fornacis*	1 55.7	—30 36	5.10	1	5.8	5.5	5.6	—	—
68	*ν Fornacis*	1 58.9	—29 54	4.44	1	5.0	4.9	5.1	—	—
69	*α Arietis*	2 0.1	+22 52	2.06	4	—	—	—	—	—
70	*μ Fornacis*	2 7.4	—31 19	5.03	1	5.4	5.4	5.6	—	—
71	*67 Ceti*	2 10.7	— 7 0	5.48	1	—	5.7	—	—	—
72	*φ Eridani*	2 12.0	—52 5	3.56	5	3.5	3.5	3.9	4.0	3.69
73	*ο Ceti*	2 13.0	— 3 33	5.35	1	—	var.	—	—	var.
74	*Ll. 4396*	2 15.9	—11 21	5.28	1	—	5.4	—	—	—
75	*Ll. 4466*	2 18.2	—16 49	5.76	1	—	6.4	—	—	—
76	*δ Hydri*	2 19.5	—69 14	4.04	4	3.8	4.1	4.4	4.0	4.07
77	*ρ Ceti*	2 19.9	— 2 51	4.61	1	—	4.6	—	—	—
78	*ξ² Ceti*	2 21.5	+ 7 54	4.12	1	—	4.4	—	—	—
79	*κ Eridani*	2 22.4	—48 17	4.06	5	4.1	4.2	4.5	4.4	var.?
80	*Ll. 4681*	2 25.0	+ 1 43	5.81	1	—	5.7	—	—	—
81	*75 Ceti*	2 25.8	— 1 35	5.57	2	—	5.9	—	—	—
82	*σ Ceti*	2 26.2	—15 48	4.86	1	—	4.8	—	—	—
83	*ω Fornacis*	2 28.4	—28 47	4.71	1	5.0	4.9	—	—	—
84	*δ Ceti*	2 33.1	— 0 13	4.20	2	—	4.0	—	—	—
85	*ε Ceti*	2 33.5	—12 24	4.55	1	—	4.6	—	—	—
86	*s Eridani*	2 35.0	—43 26	4.80	1	5.0	5.0	5.0	4.7	4.90
87	*ι Eridani*	2 35.7	—40 23	4.13	1	4.5	4.2	4.1	4.2	4.23

[1] For S.M.P. the visual mag. 4.7 was adopted. [2] Perhaps for *Hydri* (Gould.)

TABLE III — *Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
88	γ *Ceti*	2 36.8	+ 2 42	3.49	3	—	3.2	—	—	—
89	ϵ *Hydri*.....	2 37.7	—68 48	4.02	4	3.8	4.2	4.4	4.2	4.12
90	μ *Ceti*.....	2 38.2	+ 9 35	4.44	1	—	4.3	—	—	—
91	π *Ceti*	2 38.2	—14 23	4.06	2	—	4.1	—	—	—
92	τ^1 *Eridani*	2 39.3	—19 6	4.45	2	—	4.5	—	—	—
93	*Lac. 896*	2 42.8	—64 14	5.72	1	5.8	6.1	6.0	—	—
94	ζ *Hydri*.....	2 43.6	—68 8	4.90	4	4.5	5.2	5.1	5.0	—
95	τ^2 *Eridani*	2 45.4	—21 31	4.96	2	5.0	4.9	—	—	—
96	η *Eridani*.....	2 50.3	— 9 24	3.90	3	—	3.7	—	—	—
97	ν *Hydri*.....	2 51.3	—75 35	5.28	1	4.5	5.1	5.0	5.1	5.00
98	θ *Eridani*	2 53.5	—40 48	3.22	4	3.1	2.6	3.1	3.4	3.08
99	ρ^1 *Eridani*	2 55.0	— 8 9	5.90	1	—	6.1	—	—	—
100	α *Ceti*.....	2 55.7	+ 3 36	2.67	4	—	2.4	—	—	—
101	β *Horologii*.....	2 56.4	—64 34	5.44	3	5.0	5.2	5.3	—	5.23
102	ρ^2 *Eridani*	2 56.6	— 8 11	5.77	1	—	5.6	—	—	—
103	τ^3 *Eridani*	2 56.9	—24 7	4.16	2	3.8	4.1	—	—	—
104	*Br. 465*	2 57.3	—64 7	5.39	1	—	—	—	—	var.?
105	ρ^3 *Eridani*	2 58.1	— 8 6	5.68	1	—	5.3	—	—	—
106	α *Fornacis*.....	3 6.7	—29 29	3.93	1	—	3.6	—	—	—
107	ζ *Eridani*	3 9.8	— 9 17	4.85	2	—	4.9	—	—	—
108	*Lac. 1051*.....	3 12.8	—22 58	4.81	1	5.4	5.3	—	—	—
109	*Ll. 6161*.....	3 13.0	—19 1	5.72	1	—	5.8	—	—	—
110	τ^4 *Eridani*	3 13.9	—22 13	3.69	2	3.8	3.4	—	—	—
111	*e Eridani*	3 14.9	—43 33	4.56	1	5.0	4.4	4.5	4.4	4.57
112	ζ^1 and ζ^2 *Reticuli*.	3 15.2	—63 1	4.97	3	5.0	5.1	[5.5]	5.2	5.07
113	*o Tauri*.....	3 18.1	+ 8 35	3.56	1	—	3.4	—	—	—
114	ξ *Tauri*.....	3 20.4	+ 9 18	3.66	1	—	3.5	—	—	—
115	*v Eridani*.....	3 24.4	— 5 30	4.91	1	—	4.7	—	—	—
116	*Ll. 6535*	3 25.7	—13 10	5.82	1	—	—	—	—	—
117	ϵ *Eridani*	3 27.0	— 9 53	3.74	3	—	3.6	—	—	—
118	κ *Reticuli*	3 27.2	—63 23	4.91	3	4.5	5.0	5.1	5.0	4.90
119	τ^5 *Eridani*	3 28.3	—22 3	4.22	2	4.1	4.5	—	—	—
120	*Ll. 6661*	3 30.0	—11 37	5.85	1	—	5.8	—	—	—
121	*10 Tauri*.....	3 30.5	+ 0 1	3.96	1	—	4.5	—	—	—
122	*20 Eridani*.....	3 30.6	—17 53	5.31	2	—	5.3	—	—	—
123	*y Eridani*.....	3 32.6	—40 41	4.63	1	5.0	4.8	4.7	4.6	4.75
124	γ *Eridani*.....	3 35.2	—13 52	3.13	2	—	2.8	—	—	—
125	δ *Eridani*.....	3 37.3	—10 11	3.46	4	—	3.3	—	—	—
126	*17 Tauri*.....	3 37.4	+23 43	4.42	1	—	—	—	—	—
127	*Ll. 6914*	3 37.6	—10 53	5.84	1	—	5.9	—	—	—
128	*19 Tauri*.....	3 37.8	+24 4	5.09	1	—	—	—	—	—
129	*h Eridani*.....	3 38.2	—37 42	4.71	3	5.4	4.8	4.7	4.7	4.86
130	*20 Tauri*.....	3 38.4	+23 58	4.79	1	—	—	—	—	—
131	*23 Tauri*.....	3 38.9	+23 33	4.79	1	—	—	—	—	—
132	η *Tauri*.....	3 40.1	+23 43	3.13	1	—	—	—	—	—
133	π *Eridani*.....	3 40.2	—12 30	4.79	2	—	4.7	—	—	—
134	τ^6 *Eridani*	3 41.5	—23 37	4.29	2	3.8	3.9	—	—	—
135	*27 Tauri*.....	3 41.7	+23 40	3.90	1	—	—	—	—	—
136	*28 Tauri*.....	3 41.7	+23 45	5.34	1	—	—	—	—	—
137	τ^7 *Eridani*	3 42.3	—24 16	5.00	1	4.5	5.5	—	—	—
138	β *Reticuli*	3 42.6	—65 12	3.99	5	4.1	3.9	3.9	4.0	3.98
139	*f Eridani*.....	3 44.0	—38 0	4.32	2	5.0	4.3	4.8	4.3	var.?

TABLE III — *Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U. A.	S.M.P.	W.	Mean
		h m	° ′							
140	*g Eridani*	3 44.8	−36 35	4.21	2	5.0	4.1	4.3	4.1	—
141	*τ⁸ Eridani*	3 48.4	−24 59	4.75	2	3.8	4.4	5.1	—	var.?
142	*γ Hydri*	3 49.2	−74 37	3.33	10	3.1	3.2	3.1	3.2	3.19
143	*Ll. 7273*	3 49.4	−12 27	5.76	1	—	6.1	—	—	—
144	*Ll. 7422*	3 53.6	−12 56	5.76	1	—	6.1	—	—	—
145	*τ⁹ Eridani*	3 54.6	−24 22	4.63	2	3.8	4.4	—	—	—
146	*Lac. 1316*	3 55.7	−30 51	6.08	1	6.4	5.9	6.5	—	—
147	*ν Tauri*	3 56.5	+ 5 38	3.82	1	—	3.9	—	—	—
148	*δ Reticuli*	3 56.8	−61 45	4.96	2	4.5	4.7	4.5	4.8	4.69
149	*Ll. 7600*	3 58.5	−13 8	5.71	1	—	6.0	—	—	—
150	*γ Reticuli*	3 59.1	−62 30	4.67	2	4.5	4.7	4.7	4.7	4.65
151	*ι Reticuli*	3 59.3	−61 26	5.17	2	5.4	5.1	5.1	5.2	5.19
152	*Lac. 1344*	4 0.5	−28 0	5.69	1	5.8	5.8	—	—	—
153	*δ Horologii*	4 6.6	−42 19	4.90	1	5.8	5 3	5.1	4.9	—
154	*o² Eridani*	4 9.5	− 7 48	4.33	1	—	4.4	—	—	—
155	*α Horologii*	4 9.9	−42 36	3.81	1	5.0	3.8	3.9	4.1	—
156	*γ Doradûs*	4 12.7	−51 48	4.44	3	5.0	4.4	4.5	—	—
157	*α Reticuli*	4 12.8	−62 47	3.57	8	3.1	3.3	3.4	3.2	3.31
158	*ε Reticuli*	4 14.3	−59 36	4.96	3	4.5	4.6	4.6	4.8	4.69
159	*ξ Eridani*	4 17.4	− 4 2	5.24	1	—	5.6	—	—	—
160	*d Eridani*	4 19.3	−34 18	4.37	1	3.8	4.0	4.1	3.7	—
161	*Ll. 8588*	4 26.4	− 3 29	5.69	1	—	6.0	—	—	—
162	*υ¹ Eridani*	4 28.6	−30 1	5.18	1	3.8	4.7	4.8	4.6	var.?
163	*α Tauri*	4 28.7	+16 15	1.37	8	—	—	—	—	—
164	*ν Eridani*	4 30.1	− 3 37	3.89	2	—	3.8	—	—	—
165	*υ² Eridani*	4 30.7	−30 49	4.33	1	3.5	3.7	3.9	4.0	—
166	*α Doradûs*	4 31.3	−55 18	3.43	9	3.5	3.1	3.6	3.6	3.45
167	*51 Eridani*	4 31.3	− 2 40	5.54	2	—	5.8	—	—	—
168	*l Eridani*	4 32.5	−14 33	4.41	2	—	4.1	—	—	—
169	*Ll. 8809*	4 33.6	−14 36	5.69	1	—	5.6	—	—	—
170	*Lac. 1544*	4 34.9	−24 44	5.69	1	5.8	6.0	5.8	—	5.82
171	*54 Eridani*	4 35.0	−19 55	4.82	1	5.8	4.6	—	—	—
172	*α Coeli*	4 36.5	−42 6	4.77	1	5.0	4.6	4.8	4.6	4.75
173	*β Coeli*	4 37.6	−37 23	5.69	1	4.5	5.1	5.5	5.3	—
174	*Ll. 8951*	4 38.6	−18 54	5.69	1	—	5.7	—	—	—
175	*μ Eridani*	4 39.2	− 3 29	4.12	2	—	4.0	—	—	—
176	*Lac. 1585*	4 39.6	−50 43	5.73	1	5.4	5.5	5.7	—	—
177	*Ll. 8996*	4 39.7	−21 31	6.08	1	—	6.1	—	—	—
178	*58 Eridani*	4 42.0	−17 10	5.69	1	—	5.7	—	—	—
179	*π³ Orionis*	4 43.0	+ 6 44	3.11	1	—	3.1	—	—	—
180	*π² Orionis*	4 43.8	− 8 41	4.68	1	—	4.7	—	—	—
181	*μ Mensae*	4 44.3	−71 10	5.24	1	5.0	5.6	6.2	5.7	var.?
182	*π⁴ Orionis*	4 44.5	+ 5 23	3.52	1	—	3.7	—	—	—
183	*60 Eridani*	4 44.6	−16 26	5.69	1	—	5.0	—	—	—
184	*ω Eridani*	4 46.7	− 5 40	4.85	1	—	4.7	—	—	—
185	*Lac. 1628*	4 46.9	−35 7	5.69	1	5.8	6.2	6.4	6.2	var.?
186	*π⁵ Orionis*	4 47.7	+ 2 14	3.60	1	—	3.7	—	—	—
187	*π¹ Orionis*	4 48.0	− 9 57	5.00	1	—	5.0	—	—	—
188	*ι Pictoris*	4 48.1	−53 41	5.33	2	5.4	5.4	[6.1]	—	—
189	*R Leporis*	4 53.9	−15 0	5.19	1	—	var.	—	—	var.
190	*ψ Eridani*	4 55.4	− 7 21	4.82	2	—	5.3	—	—	—
191	*Lac. 1686*	4 57.1	−26 27	5.72	1	5.0	5.4	—	—	—

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P	W.	Mean
		h m	° ′							
192	η^1 *Pictoris*	4 59·5	−49 20	5.99	1	5.4	5.5	5.8	5.6	—
193	γ *Coeli*	4 59·9	−35 39	4.80	1	5.4	4.7	4.9	4.7	—
194	*Lac. 1710*	5 0.2	−26 19	6.08	1	5.8	6.1	—	—	—
195	ϵ *Leporis*	5 0.2	−22 32	3.52	3	3.1	3.1	—	—	var.?
196	β *Eridani*	5 1.7	− 5 15	2.95	5	—	2.8	—	—	—
197	η^2 *Pictoris*	5 1.7	−49 45	5.99	1	5.4	5.3	5.3	5.4	—
198	λ *Eridani*	5 3.2	− 8 55	4.75	2	—	4.6	—	—	—
199	ζ *Doradûs*	5 3.4	−57 39	4.83	2	5.0	4.8	5.0	5.0	4.93
200	β *Mensae*	5 4.3	−71 29	5.56	1	5.4	5.7	5.6	5.8	5.61
201	*Lac. 1751*	5 5.1	−55 9	5.76	1	—	—	(7.6)	—	—
202	ι *Leporis*	5 6.5	−12 1	4.71	2	—	4.4	—	—	—
203	μ *Leporis*	5 7.3	−16 21	3.60	3	—	3.4	—	—	—
204	κ *Leporis*	5 7.5	−13 5	4.71	2	—	4.2	—	—	—
205	α *Aurigae*	5 7.5	+45 52	0.87	1	—	1.0	—	—	—
206	β *Orionis*	5 8.6	− 8 21	1.00	15	—	1.0	—	—	—
207	*Lac. 1773*	5 10.1	−36 7	5.72	1	6.4	5.8	[6.3]	6.5	—
208	τ *Orioni*	5 11.5	− 6 59	4.10	1	—	3.9	—	—	—
209	λ *Leporis*	5 13.8	−13 18	4.78	2	—	4.1	—	—	—
210	θ *Doradûs*	5 13.9	−67 20	5.03	1	5.0	5.1	5.1	5.0	5.05
211	ν *Leporis*	5 14.2	−12 27	5.55	1	—	5.7	—	—	—
212	*Ll. 10063*	5 15.1	−21 22	5.72	1	5.0	4.9	—	—	—
213	*Lac. 1825*	5 16.3	−50 45	5.73	1	5.9	5.8	6.1	5.8	5.87
214	*8 Leporis*	5 17.8	−14 3	5.72	1	—	5.7	—	—	—
215	η *Orionis*	5 18.2	− 2 31	3.49	2	—	3.4	—	—	—
216	γ *Orionis*	5 18.4	+ 6 14	1.98	11	—	1.7	—	—	—
217	β *Tauri*	5 18.4	+28 30	2.09	2	—	—	—	—	—
218	*Ll. 10254*	5 20.6	−19 48	6.08	1	—	6.2	—	—	—
219	θ *Pictoris*	5 21.9	−52 26	5.73	1	5.9	6.0	[6.7]	5.8	—
220	β *Leporis*	5 22.9	−20 52	2.97	9	2.9	2.9	—	—	—
221	λ *Doradûs*	5 24.5	−59 1	5.45	1	5.4	5.6	5.4	5.6	5.49
222	δ *Orionis*	5 25.6	− 0 24	2.40	6	—	2.3	—	—	—
223	ϵ *Columbae*	5 26.8	−35 34	3.95	1	3.8	4.1	4.0	4.1	3.99
224	α *Leporis*	5 27.2	−17 55	2.68	10	—	2.7	—	—	—
225	λ *Orionis*	5 28.2	+ 9 51	3.74	1	—	3.5	—	—	—
226	θ *Orionis*	5 29.1	− 5 28	4.35	1	—	4.8	—	—	—
227	ι *Orionis*	5 29.3	− 5 59	3.05	4	—	2.9	—	—	—
228	ϵ *Orionis*	5 29.9	− 1 17	1.81	12	—	1.8	—	—	—
229	*Lac. 1904*	5 30.9	−33 21	5.72	1	5.9	6.8	(6.7)	—	var.?
230	β *Doradûs*	5 32.5	−62 34	3.84	6	3.8	3.9	3.8	4.2	—
231	σ *Orionis*	5 32.5	− 2 40	4.44	1	—	4.0	—	—	—
232	ζ *Orionis*	5 34.4	− 2 1	1.95	12	—	1.8	—	—	—
233	α *Columbae*	5 35.1	−34 8	2.83	9	2.3	2.5	2.8	2.6	—
234	*Lac. 1936*	5 35.2	−32 42	5.72	1	5.9	5.9	5.8	6.0	5.86
235	γ *Mensae*	5 36.8	−76 26	5.66	1	5.9	5.6	5.3	5.6	5.61
236	γ *Leporis*	5 39.2	−22 29	3.72	2	3.5	3.5	—	—	—
237	μ *Columbae*	5 41.3	−32 21	5.09	1	5.4	5.4	5.8	5.4	5.42
238	ζ *Leporis*	5 41.3	−14 52	3.66	2	—	3.6	—	—	—
239	κ *Orionis*	5 41.8	− 9 43	2.33	9	—	2.3	—	—	—
240	β *Pictoris*	5 44.3	−51 7	3.96	1	5.0	3.9	4.1	4.0	—
241	δ *Doradûs*	5 44.5	−65 47	4.46	4	4.5	4.5	4.8	4.8	4.61
242	δ *Leporis*	5 45.9	−20 53	3.88	2	3.8	3.7	—	—	—
243	β *Columbae*	5 46.5	−35 49	3.18	5	2.9	2.9	3.1	3.0	3.02

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P	W.	Mean
		h m	° ′							
244	*γ Pictoris*	5 47·5	−56 12	4.96	2	5.0	4.7	4.5	4.6	—
245	*Lac. 2052*.....	5 48.1	−52 8	5.73	1	5.4	5.6	5.1	5.4	5.45
246	*α Orionis*.....	5 48.4	+ 7 23	1.16	14	—	1.2	—	—	—
247	*λ Columbae*	5 48.6	−33 50	4.87	1	4.5	5.2	5.4	5.3	—
248	*ε Doradûs*.....	5 50.0	−66 56	4.87	3	5.0	5.1	5.3	5.4	var.?
249	*β Aurigae*... ..	5 50.4	+44 56	2.22	1	—	—	—	—	—
250	*η Leporis*.....	5 50.7	−14 12	3.80	2	—	3.8	—	—	—
251	*ξ Columbae*	5 51.2	−37 8	4.99	1	5.4	5.4	5.3	5.6	—
252	*σ Columbae*	5 51.6	−31 24	5.72	1	6.4	5.6	6.0	6.0	5.94
253	*Lac. 2087*	5 52.1	−52 40	5.73	1	5.4	5.8	5.6	5.4	5.59
254	*γ Columbae*.....	5 53.1	−35 18	4.61	2	4.5	4.5	4 7	4.6	4.58
255	*Lac. 2106*	5 53.1	−63 8	5.18	2	5.0	4.9	4.7	5.1	4.98
256	*η Columbae*.....	5 55.3	−42 49	4.16	2	4.1	4.0	4.2	4.3	4.15
257	*Lac. 2115*	5 58.2	−26 17	5.72	1	6.4	5.5	—	—	—
258	*Lac. 2137*	6 0.9	−45 2	5.42	1	5.0	5.8	[6.3]	5.8	—
259	*θ Columbae*.....	6 3.2	−37 14	4.89	2	5.0	5.3	5.8	5.3	var.?
260	*Lac. 2174*.....	6 4.9	−44 20	5.14	1	6.4	6.6	—	6.5	—
261	*η¹ Doradûs*	6 6.0	−66 1	5.80	1	5.9	6.0	6.3	5.0	var.?
262	*ν Doradûs*.....	6 9.5	−68 49	5.00	1	4.5	5.2	5.6	5.5	—
263	*η² Doradûs*..... ..	6 11.0	−65 34	5.83	1	5.4	5.5	5.1	6.2	—
264	*Lac. 2224*.....	6 11.2	−61 26	5.75	1	—	6.6	—	—	—
265	*κ Columbae*.....	6 12.1	−35 6	4.48	1	4.5	4.8	4.8	4.6	4.64
266	*α Mensae*.....	6 14.0	−74 43	5.62	1	5.0	5.3	5.6	5.5	5.40
267	*ζ Canis Maj*.....	6 15.5	−30 1	3.09	6	2.9	3.2	3.3	—	—
268	*β Canis Maj*.....	6 17.2	−17 54	2.29	10	—	2.2	—	—	—
269	*δ Columbae*.....	6 17.5	−33 22	3.67	1	4.1	3.9	4.0	4.1	—
270	*ν Pictoris*.....	6 20.7	−56 18	5.85	1	5.9	6.0	6.2	5.8	5.95
271	*α Argûs*.....	6 21.2	−52 38	0.44	17	1.0	0.4	(−1.0)	(−0.8)	—
272	*G Puppis*.....	6 22.4	−48 6	5.99	1	5.9	5.9	6.5	6.0	6.06
273	*Lac. 2311*.....	6 22.7	−60 13	6.21	2	5.9	6.1	6.5	5.9	6.12
274	*λ Canis Maj*	6 23.5	−32 30	5.00	1	4.5	4.7	4.9	5.0	4.82
275	*π¹ Doradûs*	6 23.8	−69 55	5.69	1	5.4	6.1	6.0	5.8	5.80
276	*Lac. 2328*.....	6 25.1	−57 55	6.36	1	5.9	6.3	6.2	6.3	6.21
277	*Lac. 2309*.....	6 25.8	−27 41	6.19	1	—	6.1	—	—	—
278	*π² Doradûs*	6 26.5	−69 37	5.69	1	5.4	5.9	5.8	5.8	—
279	*Lac. 2333*.....	6 26.7	−50 9	5.73	1	5.4	5.5	5.7	5.8	5.63
280	*Lac. 2343*.....	6 27.3	−56 46	5.98	1	5.9	6.9	5.6	5.5	var.?
281	*μ Pictoris*.....	6 30.1	−58 40	6.00	2	5.9	6.0	6.3	5.8	6.00
282	*γ Geminorum*....	6 30.5	+16 30	2.23	6	—	—	—	—	—
283	*ν¹ Canis Maj* ...	6 30.9	−18 34	5.31	1	—	6.4	—	—	—
284	*ν² Canis Maj*	6 31.2	−19 9	4.26	1	—	4.1	—	—	—
285	*N Carinae*.....	6 32.2	−52 52	4.95	2	5.0	4.8	4.7	4.7	—
286	*ν³ Canis Maj*	6 32.4	−18 8	4.75	1	—	4.9	—	—	—
287	*ν Puppis*.....	6 33.9	−43 5	3.28	6	3.5	3.5	3.3	3.2	3.36
288	*Lac. 2402*.....	6 35.3	−48 7	5.73	1	5.4	5.3	5.4	5.6	5.49
289	*α Canis Maj*.....	6 39.6	−16 33	0.10	13	—	0.1	—	—	—
290	*10 Canis Maj*.....	6 39.7	−30 57	5.86	1	5.4	5.7	5.4	5.6	5.59
291	*Lac. 2438*.....	6 40.7	−30 49	5.90	1	5.9	6.3	6.5	—	—
292	*κ Canis Maj*.....	6 45.2	−32 22	3.73	2	4.1	4.0	4.0	4.2	var.?
293	*Lac. 2479*.....	6 45.7	−31 34	5.99	1	5.9	6.3	6.2	6.0	6.08
294	*Lac. 2486*.....	6 46.3	−34 13	6.17	1	5.4	5.4	5.3	5.4	—
295	*τ Puppis*.....	6 46.8	−50 28	3.11	8	3.5	3.2	2.8	3.0	3.12

TABLE III — *Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
296	*α Pictoris*	6 46.9	−61 48	3.36	10	3.5	3.5	3.3	3.4	3.41
297	*A Carinae*	6 47.1	−53 29	5.06	2	5.0	4.8	4.6	4.8	—
298	*θ Canis Maj.*	6 48.4	−11 53	4.29	1	—	4.4	—	—	—
299	*o¹ Canis Maj*	6 48.9	−24 2	3.88	2	4.1	3.9	—	—	—
300	*Lac. 2557*	6 52.9	−48 33	5.73	1	5.4	5.5	5.3	5.7	5.53
301	*ε Canis Maj.*	6 53.7	−28 48	1.80	16	1.7	1.8	—	—	—
302	*t Puppis*	6 53.8	−33 57	6.14	1	5.4	5.4	5.6	5.5	—
303	*σ Canis Maj.*	6 56.7	−27 45	3.60	2	4.1	3.6	—	—	—
304	*o² Canis Maj*	6 57.8	−23 39	3.33	6	3.8	3.4	—	—	—
305	*Lac. 2601*	6 57.8	−51 14	5.63	2	5.9	5.8	5.4	—	5.68
306	*γ Canis Maj.*	6 58.1	−15 27	4.20	3	—	4.5	—	—	var.?
307	*Lac. 2621*	6 59.1	−58 46	5.99	1	—	6.4	—	—	—
308	*Lac. 2646*	7 0.0	−67 45	5.72	1	5.4	5.7	5.4	5.8	5.60
309	*Lac. 2608*	7 0.1	−43 26	5.73	1	5.4	5.8	5.9	6.1	—
310	*Lac. 2624*	7 0.6	−49 24	5.28	2	5.4	5.3	5.6	5.5	—
311	*Lac. 2640*	7 1.3	−59 0	5.73	1	6.4	6.0	6.3	—	—
312	*Lac. 2642*	7 2.0	−56 34	5.52	1	6.4	5.7	5.7	5.6	5.78
313	*δ Canis Maj.*	7 3.3	−26 12	2.13	17	2.0	2.1	—	—	2.08
314	*Lac. 2673*	7 7.4	−48 44	5.32	2	5.4	5.6	5.5	5.7	—
315	*I Puppis*	7 9.0	−46 33	4.93	2	5.0	4.8	4.8	5.0	4.91
316	*L¹ Puppis*	7 9.5	−44 58	5.27	2	5.0	5.3	5.5	5.5	var.?
317	*ω Canis Maj.*	7 9.7	−26 33	4.55	1	5.0	4.2	—	—	—
318	*L² Puppis*	7 9.7	−44 26	var.	3	5.0	var.	var.	—	var.
319	*γ Volantis*	7 9.8	−70 18	3.85	11	4.1	3.8	3.7	3.8	3.85
320	*Lac. 2735*	7 10.8	−62 59	6.41	1	5.9	6.3	6.5	—	—
321	*Lac. 2711*	7 11.2	−48 3	5.50	1	5.0	5.0	5.2	5.3	—
322	*Lac. 2732*	7 12.6	−46 33	5.52	1	6.4	6.1	6.1	—	—
323	*π Puppis*	7 12.7	−36 52	2.69	8	2.7	2.7	2.5	2.5	2.62
324	*δ Volantis*	7 16.9	−67 44	4.18	5	4.5	4.1	4.1	4.2	4.22
325	*Lac. 2783*	7 17.6	−51 51	5.73	1	—	5.9	6.0	—	—
326	*η Canis Maj.*	7 19.1	−29 4	2.56	8	2.7	2.9	—	—	—
327	*β Canis Min*	7 20.4	+ 8 32	3.04	4	—	3.0	—	—	—
328	*Lac. 2827*	7 22.0	−58 15	5.73	1	—	6.8	—	—	—
329	*Lac. 2829*	7 23.2	−50 47	5.52	1	5.9	5.7	5.4	—	5.63
330	*σ Puppis*	7 25.3	−43 3	3.43	7	3.5	3.5	3.0	3.4	3.37
331	*α Geminorum*	7 26.6	+32 10	1.92	5	—	—	—	—	—
332	*Ll. 14810*	7 28.7	−22 2	5.52	1	5.4	5.2	—	—	—
333	*p Puppis*	7 30.4	−28 6	4.69	1	5.0	5.3	—	—	—
334	*Q Carinae*	7 32.6	−52 15	5.63	2	5.4	5.5	5.3	—	—
335	*f Puppis*	7 32.7	−34 41	4.92	1	5.0	4.8	5.0	—	4.93
336	*α Canis Min*	7 32.8	+ 5 33	1.06	11	—	1.2	—	—	—
337	*m Puppis*	7 33.1	−25 5	5.30	1	5.4	5.4	5.0	—	—
338	*Lac. 2904*	7 33.2	−48 33	5.88	2	5.9	6.1	6.4	—	—
339	*k Puppis*	7 33.7	−26 31	3.93	3	4.1	4.0	—	—	—
340	*Lac. 2918*	7 34.8	−48 19	5.88	2	5.9	6.0	6.1	—	—
341	*α Monocerotis*	7 35.3	− 9 16	4.88	1	—	4.0	—	—	—
342	*Lac. 2923*	7 37.6	−26 3	6.22	1	6.4	6.5	—	—	—
343	*β Geminorum*	7 37.6	+28 20	1.51	8	—	—	—	—	—
344	*1 Puppis*	7 38.5	−28 7	5.37	1	5.0	5.0	—	—	—
345	*l Puppis*	7 38.8	−28 40	4.06	2	5.0	4.2	—	—	—
346	*Lac. 2940*	7 39.3	−24 23	6.02	1	6.4	6.4	—	—	—
347	*c Puppis*	7 40.8	−37 40	3.57	1	3.8	3.6	3.5	3.6	3.61

TABLE VIII — *Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
348	*o Puppis*	7 42.9	−25 38	5.18	2	5.0	5.3	—	—	—
349	*Lac. 3011*	7 43.0	−56 25	5.99	1	6.4	6.4	—	—	—
350	*ζ Volantis*	7 43.3	−72 18	4.22	6	4.5	4.3	4.0	4.1	4.22
351	*ξ Puppis*	7 44.0	−24 33	3.30	3	3.8	3.5	—	—	—
352	*Q Puppis*	7 44.6	−46 46	5.52	1	5.0	5.1	5.0	5.1	—
353	*P Puppis*	7 45.4	−46 4	4.77	2	5.0	4.3	4.3	4.3	—
354	*a Puppis*	7 47.9	−40 15	3.80	1	4.1	4.0	3.8	3.8	3.90
355	*Lac. 3074*	7 49.5	−54 3	5.99	1	5.9	6.1	6.5	6.2	—
356	*Lac. 3069*	7 49.5	−49 17	4.95	2	5.4	5.0	5.1	5.0	5.09
357	*J Puppis*	7 49.6	−47 47	4.84	2	5.0	4.5	4.5	4.5	—
358	*χ Carinae*	7 53.6	−52 39	3.65	6	4.1	3.7	3.6	3.8	3.77
359	*V Puppis*	7 54.6	−48 54	4.97	2	5.0	5.0	4.8	var.	var.
360	*Br. 1855*	7 55.6	−62 58	6.48	1	6.4	6.5	—	—	—
361	*Lac. 3134*	7 56.7	−60 29	6.06	1	—	5.0	—	—	cum.
362	*D Carinae*	7 58.7	−63 13	5.07	1	5.0	5.2	5.3	5.4	—
363	*ζ Puppis*	7 59.2	−39 39	2.42	15	2.7	2.5	2.4	2.3	2.46
364	*ρ Puppis*	8 2.2	−23 57	2.94	4	2.9	3.2	—	—	—
365	*Lac. 3163*	8 2.7	−44 54	5.73	1	5.9	5.7	5.1	—	—
366	*19 Puppis*	8 5.4	−12 33	5.16	1	—	5.2	—	—	—
367	*Lac. 3180*	8 5.5	−43 45	5.73	1	5.9	5.9	5.6	—	5.78
368	*γ Velorum*	8 5.7	−46 58	1.96	22	2.3	2.9	1.9	1.9	var.?
369	*h^1 Puppis*	8 6.9	−39 15	5.12	2	5.4	4.8	4.5	4.8	—
370	*B Carinae*	8 6.9	−60 55	5.15	2	5.4	5.3	5.1	5.1	5.21
371	*Lac. 3197*	8 7.2	−42 37	5.76	1	5.4	5.3	5.2	4.8	var.?
372	*ε Volantis*	8 7.5	−68 15	4.40	5	4.5	4.5	4.7	4.8	—
373	*h^2 Puppis*	8 9.6	−39 58	5.12	2	5.4	4.8	4.5	4.9	—
374	*β Cancri*	8 9.7	+ 9 34	3.79	1	—	3.5	—	—	—
375	*C Carinae*	8 13.4	−62 32	5.35	3	5.4	5.7	5.7	5.5	—
376	*B Velorum*	8 18.7	−48 5	5.75	2	5.4	5.4	5.2	5.3	—
377	*C Hydrae*	8 19.4	− 3 30	4.07	1	—	3.8	—	—	—
378	*ε Carinae*	8 20.0	−59 6	2.05	16	2.0	2.1	1.9	1.8	1.97
379	*$κ^1$ and $κ^2$ Volantis.*	8 20.2	−71 7	5.12	3	4.5	4.7	5.2	—	—
380	*α Chamaeleontis*	8 21.7	−76 31	4.30	5	4.1	4.2	4.2	4.3	4.22
381	*Lac. 3345*	8 22.8	−49 5	5.73	1	—	—	—	—	—
382	*η Volantis*	8 23.2	−73 0	5.58	1	5.0	5.7	5.8	5.7	5.56
383	*F Velorum*	8 24.2	−52 41	5.99	1	5.9	5.7	—	—	—
384	*θ Chamaeleontis*	8 24.3	−77 5	4.62	4	4.1	4.7	4.4	4.6	4.48
385	*β Volantis*	8 24.4	−65 43	4.13	5	4.1	3.9	3.7	3.9	—
386	*A Velorum*	8 25.1	−47 31	5.76	2	5.9	6.0	5.9	5.8	5.87
387	*C Velorum*	8 30.9	−49 31	5.88	2	5.9	5.6	5.3	5.6	—
388	*δ Hydrae*	8 31.0	+ 6 8	4.40	1	—	4.2	—	—	—
389	*Lac. 3443*	8 32.1	−50 32	5.76	1	6.4	6.4	—	6.2	—
390	*σ Hydrae*	8 32.2	+ 3 47	4.83	1	—	4.9	—	—	—
391	*e^1 Carinae*	8 32.4	−57 48	5.36	1	6.4	5.9	5.8	5.8	—
392	*e^2 Carinae*	8 32.4	−57 35	5.45	2	5.9	5.4	5.1	5.5	5.47
393	*e Velorum*	8 33.2	−42 33	5.02	2	4.5	4.6	4.3	4.6	—
394	*β Pyxidis*	8 35.2	−34 52	4.45	5	5.0	4.4	4.1	4.5	4.49
395	*b Velorum*	8 36.5	−46 12	4.43	2	4.1	4.1	3.8	4.0	—
396	*o Velorum*	8 36.7	−52 29	3.99	2	4.5	4.0	3.7	3.8	4.00
397	*η Hydrae*	8 36.7	+ 3 51	4.47	1	—	4.6	—	—	—
398	*n Velorum*	8 37.1	−46 52	5.42	2	5.4	5.2	5.1	—	—
399	*Lac. 3483*	8 37.1	−48 29	5.99	1	6.4	6.6	—	—	—

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
400	*d Carinae*	8 37.8	−59 19	4.90	1	4.5	4.7	4.6	4.8	4.70
401	*Lac. 3492*	8 38.2	−47 39	5.75	2	—	5.9	5.9	—	—
402	*α Pyxidis*	8 38.6	−32 44	4.01	5	4.1	3.8	3.8	3.8	3.90
403	*θ Volantis*	8 38.6	−69 56	5.52	1	5.4	5.6	5.6	5.6	5.54
404	*Lac. 3505*	8 38.7	−52 39	5.27	1	5.4	5.7	[6.1]	—	—
405	*D Velorum*	8 39.8	−49 22	5.64	2	5.9	5.8	5.6	—	5.74
406	*d Velorum*	8 39.9	−42 11	5.00	2	4.5	4.4	4.1	4.4	—
407	*ε Hydrae*	8 40.1	+ 6 53	3.37	1	—	3.3	—	—	—
408	*D Hydrae*	8 40.5	−13 6	4.94	1	—	4.4	—	—	—
409	*δ Velorum*	8 41.2	−54 15	2.19	15	2.3	2.2	2.1	2.0	2.16
410	*a Velorum*	8 41.8	−45 35	4.41	2	4.1	4.1	4.2	4.0	—
411	*f Carinae*	8 43.5	−56 19	5.19	2	5.4	5.1	4.9	5.0	5.12
412	*Lac. 3556*	8 45.0	−39 51	5.99	1	6.4	6.2	5.9	—	—
413	*γ Pyxidis*	8 45.2	−27 15	4.54	3	5.4	4.4	—	—	—
414	*g Velorum*	8 45.5	−44 51	5.63	2	5.9	5.7	5.3	5.5	—
415	*f Velorum*	8 46.3	−46 4	5.63	2	5.9	5.6	5.6	—	5.68
416	*ζ Hydrae*	8 48.8	+ 6 25	3.04	5	—	3.1	—	—	—
417	*17 Hydrae*	8 49.4	− 7 30	5.21	1	—	6.5	—	—	—
418	*Lac. 3597*	8 49.6	−47 3	5.73	1	5.9	5.8	5.7	—	5.78
419	*δ Pyxidis*	8 50.2	−27 12	5.05	1	5.9	5.4	—	—	—
420	*c Carinae*	8 52.2	−60 10	4.33	1	4.5	4.0	4.1	4.3	4.25
421	*H Velorum*	8 52.6	−52 15	5.46	2	5.4	5.4	5.0	—	—
422	*b¹ Carinae*	8 53.9	−58 45	5.65	2	5.4	5.4	5.5	5.0	—
423	*Lac. 3635*	8 54.6	−46 45	5.73	1	5.9	5.9	5.6	—	—
424	*w Velorum*	8 55.4	−40 46	5.73	1	5.4	5.2	4.6	—	—
425	*b² Carinae*	8 56.3	−58 36	5.65	2	5.9	5.7	5.6	5.3	—
426	*Lac. 3651*	8 56.7	−41 23	5.90	1	6.4	6.2	6.1	—	—
427	*Lac. 3667*	8 57.9	−51 42	5.88	2	6.4	5.9	5.8	—	—
428	*c Velorum*	8 59.8	−46 36	4.51	2	4.5	4.6	3.9	3.9	—
429	*α Volantis*	9 0.5	−65 54	4.20	5	4.5	4.2	4.3	4.2	4.28
430	*λ Velorum*	9 3.4	−42 56	2.28	10	2.0	2.5	2.2	2.2	2.24
431	*E Carinae*	9 4.6	−70 2	5.33	1	5.4	5.2	5.1	4.8	—
432	*G Carinae*	9 4.8	−72 6	5.17	2	4.5	4.8	4.8	4.7	—
433	*a Carinae*	9 7.7	−58 27	3.85	2	4.1	3.8	3.6	3.8	3.83
434	*i Carinae*	9 8.4	−61 48	4.33	1	4.1	4.3	4.4	4.7	—
435	*β Carinae*	9 11.8	−69 12	1.96	20	1.7	2.0	1.9	1.7	1.85
436	*g Carinae*	9 12.7	−57 1	5.10	2	4.5	4.8	4.4	4.8	—
437	*α Lyncis*	9 13.4	+34 55	3.03	1	—	—	—	—	—
438	*ι Carinae*	9 13.7	−58 45	2.44	10	2.7	2.5	2.3	2.2	—
439	*Lac. 3846*	9 17.6	−74 22	5.81	1	5.0	5.7	5.8	5.5	—
440	*k Carinae*	9 18.0	−61 52	5.52	1	5.9	5.5	5.1	5.3	—
441	*κ Velorum*	9 18.2	−54 29	2.65	8	2.9	2.7	2.6	2.4	2.65
442	*α Hydrae*	9 21.4	− 8 7	2.10	16	—	2.1	—	—	—
443	*τ¹ Hydrae*	9 22.8	− 2 13	5.07	1	—	4.8	—	—	—
444	*τ² Hydrae*	9 25.6	− 0 38	4.72	1	—	4.8	—	—	—
445	*ψ Velorum*	9 25.8	−39 55	3.88	5	3.8	3.7	3.6	3.7	3.74
446	*Lac. 3914*	9 25.9	−71 4	5.81	1	6.4	6.0	5.8	5.9	5.98
447	*N Velorum*	9 27.4	−56 29	3.22	4	3.5	3.2	3.0	var.	var ?
448	*ι Chamaeleontis*	9 28.2	−80 15	5.58	1	5.0	5.8	5.7	6.2	—
449	*R Carinae*	9 29.1	−62 14	5.07	1	—	var.	var.	var.	var.
450	*Lac. 3917*	9 29.3	−48 27	5.44	1	5.4	5.6	5.7	5.6	—
451	*k Carinae*	9 30.8	−58 40	4.83	2	4.5	4.9	4.4	4.4	—

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean.
		h m	° ′							
452	*M Velorum*	9 32.3	−48 48	5.07	1	5.0	4.9	4.7	4.8	4.89
453	*y Velorum*	9 33.1	−42 38	6.09	1	6.4	6.0	5.8	6.3	6.12
454	*ι Hydrae*	9 33.5	− 0 34	4.04	3	—	3.9	—	—	—
455	*I Hydrae*	9 35.6	− 23 1	5.13	2	5.0	5.2	—	—	—
456	*m Carinae*	9 35.9	−60 46	5.07	1	5.0	5.1	4.8	4.6	—
457	*LI. 19093*	9 36.6	−23 22	5.13	2	5.0	5.4	—	—	—
458	*ζ Chamaeleontis*...	9 37.5	−80 23	5.81	1	5.0	5.5	5.6	5.4	—
459	*e Leonis*	9 38.7	+24 21	3.07	1	—	—	—	—	—
460	*Lac. 4022*	9 41.6	−44 11	5.78	1	5.9	6.0	6.2	6.0	—
461	*l Carinae*	9 41.8	−61 56	3.83	2	4.5	4.4	var.	var.	var.
462	*v Carinae*	9 44.0	−64 29	3.12	8	—	3.3	3.0	2.8	3.05
463	*u Velorum*	9 45.1	−45 9	5.56	1	5.9	5.6	5.7	—	5.69
464	*υ¹ Hydrae*	9 45.5	−14 16	4.23	2	—	4.0	—	—	—
465	*Lac. 4055*	9 46.5	−45 37	5.96	1	6.4	6.2	6.1	—	—
466	*m Velorum*.....	9 46.8	−45 58	5.14	1	5.4	4.8	4.7	—	—
467	*Lac. 4068*	9 49.4	−44 42	6.24	1	6.4	6.1	6.3	—	—
468	*φ Velorum*	9 52.5	−53 58	3.91	2	4.1	3.9	3.8	3.6	—
469	*Lac. 4094*	9 52.6	−52 3	6.43	1	6.4	6.5	--	—	—
470	*η Antliae*.....	9 53.5	−35 18	5.21	1	5.9	5.6	5.7	5.8	—
471	*Lac. 4123*	9 57.1	−52 46	6.46	1	6.4	6.5	—	—	—
472	*υ² Hydrae*	9 59.0	−12 28	4.95	1	—	4.6	—	—	—
473	*G. 1186*	10 1.2	−46 46	6.07	1	6.4	5.7	5.6	—	—
474	*α Sextantis*	10 1.5	+ 0 14	4.50	1	—	4.9	—	—	—
475	*α Leonis*	10 1.7	+12 35	1.66	8	—	—	—	—	—
476	*μ Chamaeleontis*..	10 4.0	−81 37	5.58	1	5.0	6.0	6.0	6.0	—
477	*Q Velorum*.....	10 4.2	−51 12	5.62	1	5.4	5.3	5.5	5.4	5.44
478	*Lac. 4246*	10 6.4	−80 57	5.33	1	6.4	7.0	7.0	6.6	var.?
479	*Lac. 4206*	10 8.6	−50 37	5.74	1	5.9	5.8	6.0	5.6	5.81
480	*Lac. 4208*	10 8.7	−51 8	5.82	1	6.4	6.2	6.5	—	—
481	*q Velorum*.....	10 9.5	−41 30	4.34	3	3.8	4.0	4.1	4.1	4.07
482	*M Carinae*.....	10 10.0	−65 45	5.81	1	6.4	5.7	5.8	5.7	5.88
483	*Lac. 4222*	10 10.3	−42 29	6.05	1	5.9	6.2	6.1	—	6.06
484	*ω Carinae*.....	10 10.8	−69 25	3.39	7	3.5	3.6	3.7	3.2	3.48
485	*q Carinae*	10 12.9	−60 42	3.40	6	3.8	3.3	3.5	3.8	3.56
486	*γ Leonis*	10 13.1	+20 28	2.12	8	—	—	—	—	—
487	*μ Ursae Maj*.....	10 14.8	+42 8	2.99	1	—	—	—	—	—
488	*Lac. 4263*	10 14.9	−54 24	5.52	1	5.4	5.4	4.7	5.4	—
489	*J Velorum*.....	10 16.3	−55 25	5.07	1	4.5	5.0	4.7	5.3	var.?
490	*L Carinae*.....	10 19.3	−66 16	5.67	2	5.9	5.4	5.8	5.7	5.69
491	*μ Hydrae*	10 20.0	−16 12	4.03	2	—	4.0	—	—	—
492	*α Antliae*.....	10 21.4	−30 26	4.66	1	4.5	4.4	4.4	4.0	var.?
493	*I Carinae*	10 21.9	−73 24	4.24	3	5.0	4.3	[4.2]	3.7	var.?
494	*Lac. 4310*	10 22.7	−57 0	5.52	1	5.4	5.4	5.3	5.2	5.36
495	*s Carinae*	10 23.3	−58 6	4.33	1	4.5	4.6	4.2	4.2	4.37
496	*K Carinae*	10 27.2	−71 21	5.33	2	5.4	5.0	5.3	5.0	5.21
497	*p Carinae*	10 27.6	−61 3	3.68	3	3.8	3.6	3.7	3.5	3.66
498	*Lac. 4344*	10 27.7	−46 22	5.50	1	5.9	5.6	5.5	5.4	5.58
499	*Lac. 4367*	10 28.1	−72 35	5.81	1	5.9	5.6	5.1	5.4	—
500	*Lac. 4375*	10 31.1	−57 35	5.07	1	—	5.7	—	—	—
501	*p Velorum*.....	10 32.0	−47 35	4.24	1	4.5	4.1	4.2	3.9	—
502	*l² Carinae*.....	10 34.0	−58 32	5.52	1	5.4	5.2	5.0	5.4	5.30
503	*γ Chamaeleontis*..	10 34.0	−77 58	4.47	4	5.0	4.4	4.3	4.3	4.49

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
504	*x Velorum*	10 34.3	−54 57	4.90	1	4.5	4.8	4.6	4.4	—
505	*θ Carinae*	10 38.5	−63 44	2.93	6	3.1	2.9	3.0	2.6	2.91
506	*Lac. 4455*	10 39.6	−63 18	5.76	1	6.4	5.6	5.5	—	—
507	*η Argûs*	10 40.2	−59 2	var.	21	var.	var.	var.	—	var.
508	*μ Velorum*	10 41.4	−48 46	2.76	11	3.1	2.9	2.8	2.6	2.83
509	*Lac. 4473*	10 41.9	−63 36	5.52	1	—	5.8	5.9	—	—
510	*ν Hydrae*	10 43.4	−15 32	3.19	6	—	3.0	—	—	—
511	*δ Chamaeleontis*	10 44.6	−79 53	4.29	4	5.0	4.5	[4.9]	4.9	—
512	*λ Hydrae*	10 45.0	−11 44	3.74	3	—	3.4	—	—	—
513	*u Carinae*	10 48.4	−58 11	4.07	2	4.1	4.0	4.0	4.3	4.09
514	*α Crateris*	10 53.7	−17 38	4.21	2	—	4.4	—	—	—
515	*β Ursae Maj*	10 54.3	+57 3	2.42	2	—	—	—	—	—
516	*α Ursae Maj*	10 56.0	+62 25	1.91	3	—	—	—	—	—
517	*Lac. 4604*	11 1.2	−58 0	5.33	1	—	6.5	6.5	—	—
518	*z Carinae*	11 1.4	−61 45	5.58	1	5.4	5.3	5.1	—	—
519	*Lac. 4613*	11 1.4	−64 10	5.81	1	—	7.0	—	—	—
520	*ψ Ursae Maj*	11 2.6	+45 11	2.94	2	—	—	—	—	—
521	*x Carinae*	11 3.3	−58 18	4.52	1	4.5	4.6	4.2	—	4.46
522	*Lac. 4629*	11 3.4	−61 16	5.81	1	5.9	6.0	5.9	—	5.90
523	*β Crateris*	11 5.5	−22 9	4.57	3	3.8	4.6	—	—	—
524	*y Carinae*	11 7.2	−59 38	5.07	1	5.4	5.2	5.0	—	5.17
525	*δ Leonis*	11 7.4	+21 12	2.54	3	—	—	—	—	—
526	*Lac. 4657*	11 7.6	−63 29	5.81	1	5.9	5.7	6.0	5.9	5.86
527	*θ Leonis*	11 7.7	+16 3	3 39	1	—	—	—	—	—
528	*φ Leonis*	11 10.3	− 2 58	4.61	1	—	4.2	—	—	—
529	*ξ Ursae Maj*	11 11.5	+32 14	3.45	1	—	—	—	—	—
530	*δ Crateris*	11 13.1	−14 6	3.49	3	—	3.8	—	—	—
531	*π Centauri*	11 15.3	−53 43	4.33	1	4.5	4.3	4.6	4.5	4.45
532	*ι Leonis*	11 17.4	+11 13	3.70	1	—	—	—	—	—
533	*γ Crateris*	11 18.6	−17 0	4.14	1	—	4.2	—	—	—
534	o^1 *and* o^2 *Centauri*	11 26.0	−58 45	5.43	2	5.9	5.2	5.3	5.8	—
535	*Br. 3634*	11 26.1	−59 55	5.58	1	—	—	[7.5]	—	—
536	*ξ Hydrae*	11 26.9	−31 10	3.65	2	3.5	3.7	3.7	3.1	var.?
537	*A Centauri*	11 28.8	−53 34	4.90	1	5.0	5.2	5.1	5.4	—
538	*Lac. 4798*	11 29.5	−60 12	5.58	1	—	—	[6.7]	—	—
539	*Lac. 4801*	11 29.9	−60 36	5.58	1	—	—	—	—	—
540	*λ Centauri*	11 30.0	−62 20	3.35	4	3.8	3.4	3.4	3.4	3.47
541	*θ Crateris*	11 30.3	− 9 7	5.00	1	—	5.0	—	—	—
542	*υ Leonis*	11 30.5	− 0 8	4.30	1	—	4.4	—	—	—
543	*Br. 3689*	11 32.3	−61 8	5.58	1	—	6.0	5.8	6.1	—
544	*Lac. 4843*	11 33.7	−64 42	5.81	1	5.4	5.8	5.5	6.0	5.70
545	*Lac. 4868*	11 37.6	−61 48	5.58	1	5.9	5.8	5.6	5.7	5.72
546	*ζ Crateris*	11 38.4	−17 39	5.08	1	—	5.2	—	—	—
547	*λ Muscae*	11 39.7	−66 2	3.89	3	4.1	3.8	3.9	4.2	3.98
548	*Lac. 4885*	11 40.5	−60 29	4.84	2	4.5	4.7	4.5	4.6	4.63
549	*Lac. 4899*	11 42.2	−66 7	5.79	2	5.4	5.3	5.0	5.5	—
550	*β Leonis*	11 42.7	+15 16	2.21	7	—	—	—	—	—
551	*Lac. 4903*	11 43.6	−63 5	4.93	2	4.5	4.9	4.9	4.9	4.83
552	*Ll. 22339*	11 44.0	−15 10	4.88	1	—	6.5	—	—	—
553	*Lac. 4907*	11 44.0	−69 32	5.81	1	5.9	5.6	5.3	5.8	—
554	*β Virginis*	11 44.2	+ 2 28	3.58	3	—	3.7	—	—	—
555	*Lac. 4920*	11 45.7	−64 31	5.55	2	5.4	5.4	5.5	5.4	5.45

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
556	*β Hydrae*	11 46.6	−33 13	3.92	1	4.5	4.5	4.7	4.1	—
557	*γ Ursae Maj*.....	11 47.2	+54 23	2.36	3	—	—	—	—	—
558	*ε Chamaeleontis*...	11 53.5	−77 31	4.83	4	5.4	4.9	[5.4]	5.5	—
559	*θ*¹ *Crucis*.	11 56.7	−62 37	5.20	2	5.0	4.7	4.7	4.8	—
560	*θ*² *Crucis*.....	11 57.9	−62 28	5.55	2	5.4	5.3	5.3	5.1	—
561	*κ Chamaeleontis*...	11 58.3	−75 50	5.76	1	5.9	5.6	5.3	5.8	5.67
562	*η Crucis*.....	12 0.4	−63 55	4.61	3	4.1	4.7	4.5	4.5	4.48
563	*δ Centauri*.....	12 1.9	−50 2	2.68	10	2.9	2.8	2.8	2.4	2.72
564	*α Corvi*.....	12 2.0	−24 2	4.20	3	4.1	4.2	—	—	—
565	*ε Corvi*.....	12 3.7	−21 55	2.89	10	2.9	3.3	—	—	—
566	*ρ Centauri*.....	12 5.1	−51 40	4.24	2	4.1	4.5	4.3	4.5	—
567	*Lac. 5072*	12 7.6	−65 51	5.76	1	—	6.8	—	—	—
568	*δ Crucis*.....	12 8.5	−58 3	3.19	10	3.1	3.4	3.1	3.0	3.16
569	*γ Corvi*.....	12 9.4	−16 51	2.56	9	—	2.5	—	—	—
570	*ε Muscae*	12 10.8	−67 16	4.84	2	4.5	4.7	4.3	4.8	—
571	*β Chamaeleontis* ..	12 11.0	−78 37	4.42	4	5.0	4.6	4.6	4.8	4.68
572	*δ Ursae Maj*.....	12 11.6	+57 28	3.15	2	—	—	—	—	—
573	*ζ Crucis*.....	12 11.7	−63 18	4.53	3	4.5	4.6	4.5	4.3	4.49
574	*F Centauri*	12 12.3	−54 27	5.52	1	6.4	5.8	5.3	5.9	—
575	*η Virginis*.....	12 13.5	+ 0 2	3.69	4	—	4.0	—	—	—
576	*ζ Corvi*.....	12 14.1	−21 31	5.41	1	5.4	5.3	—	—	—
577	*ε Crucis*.....	12 14.6	−59 43	3.92	7	4.1	4.0	3.6	3.7	—
578	*ζ*² *Muscae*.....	12 15.2	−66 50	5.55	2	5.4	5.8	5.7	5.6	5.61
579	*x*¹ *Centauri*.....	12 17.0	−34 43	4.72	1	5.9	5.5	5.8	5.7	—
580	Unknown.....	12 18.	−53 41	5.58	1	—	—	—	—	—
581	*α Crucis*.....	12 19.7	−62 24	1.32	20	1.0	1.3	1.3	1.3	1.24
582	*G Centauri*.....	12 19.8	−50 45	4.78	1	5.4	5.7	5.4	5.3	—
583	*σ Centauri*.....	12 21.3	−49 32	4.50	4	5.0	4.3	4.3	4.1	—
584	*Lac. 5172*.....	12 23.3	−60 18	5.67	1	—	—	[6.9]	—	—
585	*δ Corvi*.....	12 23.4	−15 49	2.83	9	—	3.0	—	—	—
586	*γ Crucis*.....	12 24.2	−56 25	1.78	16	1.7	2.0	1.7	1.7	1.78
587	*Lac. 5185*.....	12 24.7	−58 44	5.51	1	6.4	6.4	—	6.3	—
588	*γ Muscae*.....	12 25.0	−71 26	4.20	5	4.1	4.0	4.2	3.9	4.08
589	*η Corvi*.....	12 25.7	−15 30	4.72	2	—	4.5	—	—	—
590	*β Corvi*.....	12 27.8	−22 42	2.61	10	2.3	2.6	—	—	—
591	*Lac. 5208*.....	12 28.4	−61 3	5.67	1	6.4	6.2	—	—	—
592	*α Muscae*.....	12 29.7	−68 27	2.95	6	3.1	2.9	2.9	3.1	2.99
593	*τ Centauri*.....	12 30.9	−47 51	4.97	2	4.5	4.4	4.2	4.1	—
594	*γ Centauri*.....	12 34.6	−48 16	2.30	15	2.9	2.4	2.4	2.2	—
595	*Lac. 5241*.....	12 34.8	−59 0	5.51	1	5.9	6.0	5.4	5.8	—
596	*γ Virginis*.....	12 35.3	− 0 46	2.72	9	—	3.1	—	—	—
597	*ι Crucis*	12 38.3	−60 18	5.52	1	5.9	5.7	5.0	5.3	—
598	*β Muscae*.....	12 38.6	−67 25	3.26	7	3.8	3.4	3.3	3.2	—
599	*Lac. 5273*.....	12 39.2	−55 48	5.51	2	5.4	5.4	5.3	5.2	—
600	*β Crucis*.....	12 40.4	−59 0	1.64	19	1.7	1.7	1.7	1.6	1.67
601	*Lac. 5305*.....	12 45.8	−54 16	5.49	1	—	6.0	—	—	—
602	*κ Crucis (Cl.)*.....	12 46.4	−59 42	4.90	1	5.4	5.6	[6.3]	5.1	—
603	*n Centauri*.....	12 46.5	−39 30	4.92	1	5.0	4.4	4.5	4.6	—
604	*μ Crucis*.....	12 47.3	−56 30	4.16	4	4.1	4.1	[4.5]	4.1	4.12
605	*λ Crucis*.....	12 47.3	−58 28	4.90	1	5.4	5.6	5.2	5.1	—
606	*ε Ursae Maj*.....	12 48.6	+56 38	1.89	3	—	—	—	—	—
607	*δ Virginis*.....	12 49.3	+ 4 5	3.44	3	—	3.5	—	—	—

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
608	*H Centauri*.....	12 49.9	−50 31	5.65	1	5.9	5.8	5.6	5.6	5.71
609	*α Canum Venat*...	12 50.2	+39 0	2.81	3	—	—	—	—	—
610	*δ Muscae*.....	12 53.7	−70 52	4.00	5	4.1	3.6	[3.7]	3.7	—
611	*ε Virginis*.....	12 55.9	+11 38	2.79	1	—	—	—	—	—
612	*ξ¹ Centauri*.....	12 56.3	−48 51	5.46	1	5.9	5.8	5.4	5.3	—
613	*f Centauri*.....	12 59.0	−47 47	4.42	1	5.4	5.3	5.3	5.3	—
614	*ξ² Centauri*.....	12 59.6	−49 14	4.37	1	5.4	4.8	4.6	4.5	—
615	Unknown.....	13 3.	−43 44	6.28	1	—	—	—	—	—
616	*Lac. 5420*.....	13 4.0	−41 34	6.26	1	6.4	6.1	6.3	—	6.27
617	*Lac. 5422*.....	13 4.2	−42 42	6.20	1	6.4	5.7	5.5	6.4	—
618	*Lac. 5418*.....	13 4.5	−59 15	4.90	1	5.4	5.4	5.0	5.2	—
619	*Lac. 5429*.....	13 5.1	−37 8	5.90	1	5.9	5.3	5.1	5.6	—
620	*Lac. 5437*.....	13 6.5	−58 26	5.52	1	5.9	5.9	5.4	5.4	—
621	*η Muscae*.....	13 6.8	−67 14	5.07	1	5.4	5.3	5.3	5.1	5.23
622	*Lac. 5460*.....	13 9.3	−44 3	6.30	1	—	—	—	—	—
623	*r Centauri*.....	13 9.9	−30 51	5.87	1	5.9	5.7	5.5	6.0	—
624	*γ Hydrae*.....	13 12.1	−22 31	3.11	6	3.5	3.2	—	—	—
625	*ι Centauri*.....	13 13.6	−36 3	2.93	9	3.1	3.0	3.0	3.0	3.01
626	*J Centauri*.....	13 14.6	−60 20	4.90	1	5.4	5.2	4.8	5.0	5.06
627	*m Centauri*.....	13 15.6	−63 53	4.90	1	5.0	5.2	4.7	5.6	—
628	*α Virginis*.....	13 18.6	−10 30	1.43	13	—	1.5	—	—	—
629	*ζ Ursae Maj*.....	13 18.9	+55 35	2.15	3	—	—	—	—	—
630	*Lac. 5531*.....	13 18.9	−39 6	6.24	1	6.4	5.9	5.5	5.9	—
631	*ω Centauri*.....	13 19.3	−46 50	4.71	1	—	4.	—	—	—
632	*κ Centauri*.....	13 21.8	−50 31	5.92	1	5.9	5.8	5.7	5.8	5.82
633	*d Centauri*.....	13 23.8	−38 46	4.49	2	4.1	4.5	4.1	4.6	4.36
634	*ζ Virginis*.....	13 28.3	+ 0 3	3.35	4	—	3.6	—	—	—
635	*e Centauri*.....	13 32.0	−52 50	2.47	11	2.9	2.6	2.6	2.6	2.63
636	*i Centauri*.....	13 38.6	−32 25	4.41	2	4.5	4.5	4.5	4.8	—
637	*M Centauri*.....	13 38.7	−50 48	5.48	2	5.4	5.2	4.9	5.3	—
638	*s Centauri*.....	13 39.7	−35 38	5.71	2	5.4	5.8	5.6	5.6	5.62
639	*Lac. 5674*.....	13 39.8	−49 42	6.22	1	—	6.0	6.0	—	—
640	*ν Centauri*.....	13 42.0	−41 4	3.50	8	4.1	3.7	3.6	3.6	3.70
641	*μ Centauri*.....	13 42.1	−41 51	3.49	8	3.8	3.4	3.4	3.3	3.48
642	*g Centauri*.....	13 42.2	−33 49	4.40	1	4.5	4.6	4.5	4.8	—
643	*η Ursae Maj*.....	13 42.6	+49 56	2.05	3	—	—	—	—	—
644	*N Centauri*.....	13 44.0	−52 11	5.80	2	6.4	5.9	5.8	5.6	5.90
645	*k Centauri*.....	13 44.6	−32 22	4.39	2	5.0	4.7	4.6	5.0	—
646	*Lac. 5711*.....	13 45.6	−52 45	6.10	1	5.9	6.5	6.5	6.1	6.22
647	*h Centauri*.....	13 46.0	−31 19	4.60	2	5.4	5.2	5.2	5.4	—
648	*y Centauri*.....	13 46.2	−35 3	5.46	1	6.4	6.0	6.2	6.3	—
649	*Lac. 5727*.....	13 47.1	−51 33	6.10	1	6.4	6.1	6.3	5.7	—
650	*ζ Centauri*.....	13 47.7	−46 40	2.68	11	2.9	2.7	2.8	2.8	2.78
651	*Lac. 5733*.....	13 48.6	−63 4	5.52	1	5.4	5.7	5.1	5.9	—
652	*η Bootis*.....	13 48.7	+19 2	2.86	1	—	—	—	—	—
653	*φ Centauri*.....	13 50.7	−41 29	3.92	7	4.5	4.1	4.2	4.1	4.16
654	*υ¹ Centauri*.....	13 51.0	−44 11	4.23	5	4.5	4.2	4.2	4.0	4.23
655	*υ² Centauri*.....	13 53.9	−45 0	4.84	3	5.0	5.0	4.7	4.4	—
656	*β Centauri*.....	13 55.0	−59 46	1.24	17	1.0	1.2	1.2	1.2	1.17
657	*Lac. 5787*.....	13 55.3	−51 27	6.15	1	—	—	—	—	—
658	*χ Centauri*.	13 58.4	−40 35	4.54	2	5.0	4.8	4.9	5.1	—
659	*π Hydrae*.....	13 59.2	−26 5	3.40	2	3.8	3.6	—	—	—

TABLE III—*Continued.*

No.	Name	R. A.	Dec.	h.	n.	B.	U. A.	S.M.P.	W.	Mean
		h m	° ′							
660	*θ Centauri*	13 59.3	−35 45	2.20	13	2.7	2.2	2.2	2.3	2.32
661	*Lac. 5825*	14 1.4	−50 55	6.12	1	6.4	6.3	—	—	—
662	*Lac. 5827*	14 1.6	−52 51	5.52	1	—	5.4	5.2	—	—
663	*Lac. 5840*	14 4.9	−53 5	6.50	1	6.4	6.1	5.9	—	—
664	*κ Virginis*	14 6.2	− 9 41	4.28	1	—	4.2	—	—	—
665	*Lac. 5850*	14 6.3	−56 30	5.59	1	5.9	5.6	5.6	5.8	5.70
666	*ι Virginis*	14 9.5	− 5 24	4.16	1	—	4.1	—	—	—
667	*α Bootis*	14 10.0	+19 50	0.79	10	—	—	—	—	—
668	*ι Lupi*	14 11.4	−45 29	3.72	4	4.5	3.8	4.1	3.6	—
669	*υ Centauri*	14 11.6	−55 48	4.48	2	5.4	5.0	4.6	4.8	—
670	*λ Bootis*	14 11.6	+46 40	3.50	1	—	—	—	—	—
671	*λ Virginis*	14 12.3	−12 48	4.49	1	—	5.0	—	—	—
672	*Lac. 5891*	14 12.7	−44 36	5.27	1	5.9	5.7	5.1	5.5	—
673	*ψ Centauri*	14 13.0	−37 18	4.54	1	4.5	4.4	4.4	5.0	—
674	*Lac. 5893*	14 13.7	−57 53	5.56	2	5.4	5.6	5.3	5.6	5.49
675	*a Centauri*	14 15.3	−38 56	4.58	1	5.0	4.9	4.9	5.5	var.?
676	*τ¹ Lupi*	14 18.1	−44 39	5.42	2	5.4	5.3	4.9	5.1	—
677	*τ² Lupi*	14 18.1	−44 49	5.24	2	5.4	4.9	4.6	4.9	—
678	*σ Lupi*	14 24.2	−49 54	4.83	2	5.0	5.2	4.9	4.8	4.95
679	*γ Bootis*	14 27.1	+38 51	2.96	2	—	—	—	—	—
680	*η Centauri*	14 27.6	−41 36	2.64	9	2.9	2.5	2.6	2.7	2.67
681	*ρ Lupi*	14 29.5	−48 53	4.47	2	5.0	4.5	4.2	4.6	—
682	*α Centauri*	14 31.1	−60 19	0.66	18	1.0	0.7	(0.20)	(0.55)	—
683	*α Circini*	14 32.4	−64 26	3.40	5	3.5	3.5	3.4	3.7	3.50
684	*α Apodis*	14 32.4	−78 31	4.38	2	4.1	4.0	3.9	3.7	—
685	*α Lupi*	14 33.6	−46 51	2.47	9	2.7	2.6	2.5	2.5	2.55
686	*b Centauri*	14 34.2	−37 15	4.24	1	4.5	4.2	4.4	5.3	—
687	*c¹ Centauri*	14 36.0	−34 38	4.25	2	4.5	4.3	3.9	4.5	—
688	*μ Virginis*	14 36.5	− 5 7	4.05	1	—	4.0	—	—	—
689	*ε Bootis*	14 39.5	+27 36	2.45	3	—	—	—	—	—
690	*109 Virginis*	14 39.9	+ 2 25	3.80	1	—	4.0	—	—	—
691	*o Lupi*	14 43.5	−43 3	5.08	1	5.0	5.0	4.7	5.0	4.96
692	*α Librae*	14 43.8	−15 29	2.86	3	—	3.0	—	—	—
693	*β Lupi*	14 50.3	−42 38	2.89	8	3.1	2.8	2.8	2.7	2.86
694	*16 Librae*	14 50.7	− 3 50	5.45	1	—	4.8	—	—	—
695	*κ Centauri*	14 51.0	−41 36	3.20	7	3.8	3.3	3.4	3.2	—
696	*β Ursae Min.*	14 51.1	+74 40	2.12	2	—	—	—	—	—
697	*δ Librae*	14 54.3	− 8 1	var.	1	—	var.	—	—	var.
698	*π Lupi*	14 56.6	−46 34	4.04	3	5.0	4.3	4.0	4.5	—
699	*20 Librae*	14 56.7	−24 47	3.36	1	3.5	3.5	3.2	—	3.39
700	*β Bootis*	14 57.2	+40 53	3.31	1	—	—	—	—	—
701	*λ Lupi*	15 0.4	−44 48	4.29	3	5.0	4.8	4.6	4.6	—
702	*κ Lupi*	15 3.2	−48 16	3.75	4	4.5	4.1	[4.4]	4.1	—
703	*ζ Lupi*	15 3.3	−51 37	3.63	6	3.8	3.6	3.5	3.4	3.59
704	*e Lupi*	15 4.4	−44 2	5.43	1	6.4	3.5	5.3	5.5	—
705	*ι Librae*	15 5.1	−19 19	4.85	1	—	5.0	—	—	—
706	*δ Circini*	15 6.9	−60 29	5.52	1	5.4	5.4	[5.6]	5.1	—
707	*γ Trianguli*	15 7.3	−68 13	3.12	5	3.1	3.1	3.0	3.3	3.12
708	*β Circini*	15 7.7	−58 20	4.90	1	4.5	4.7	4.2	4.5	—
709	*μ Lupi*	15 9.9	−47 25	3.96	2	5.0	4.8	4.4	4.9	—
710	*β Librae*	15 10.3	− 8 55	2.82	3	—	3.1	—	—	—
711	*δ Bootis*	15 10.5	+33 47	3.27	1	—	—	—	—	—

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
712	δ *Lupi*	15 13.2	−40 12	3.43	6	4.1	3.6	3.4	3.5	—
713	γ *Circini*	15 13.4	−58 52	4.90	1	5.0	5.2	4.7	5.0	4.96
714	ϕ^1 *Lupi*	15 13.9	−35 48	3.81	3	4.5	3.6	3.3	3.8	—
715	ε *Lupi*	15 14.2	−44 14	3.57	6	4.1	3.7	3.6	3.7	3.73
716	ϕ^2 *Lupi*	15 15.2	−36 25	5.00	1	5.9	5.1	5.0	5.5	—
717	ε *Trianguli*	15 25.3	−65 54	4.99	2	5.0	4.6	4.2	4.7	—
718	γ *Lupi*	15 26.8	−40 45	3.06	8	3.5	3.2	3.0	2.9	—
719	*d Lupi*	15 27.3	−44 32	5.16	1	5.4	5.1	5.1	5.4	5.23
720	γ *Librae*	15 28.5	−14 22	4.10	1	—	4.4	—	—	—
721	δ *Serpentis*	15 28.8	+10 57	3.71	1	—	—	—	—	—
722	α *Coronae Bor*	15 29.4	+27 8	2.39	2	—	—	—	—	—
723	υ *Librae*	15 29.4	−27 43	4.32	2	4.5	3.9	—	—	—
724	ω *Lupi*	15 29.6	−42 9	5.12	1	5.4	4.7	4.2	5.3	—
725	*g Lupi*	15 32.6	−44 15	5.19	1	5.4	5.2	4.8	5.4	—
726	α *Serpentis*	15 38.1	+ 6 49	2.81	2	—	2.6	—	—	—
727	β *Serpentis*	15 40.4	+15 49	3.42	1	—	—	—	—	—
728	*Ll. 28745*	15 40.4	+ 7 45	5.31	1	—	4.8	—	—	—
729	μ *Serpentis*	15 43.1	− 3 3	3.39	1	—	3.3	—	—	—
730	β *Trianguli*	15 44.1	−63 2	3.07	5	3.1	3.1	3.1	3.3	3.13
731	ε *Serpentis*	15 44.6	+ 4 51	3.85	1	—	3.7	—	—	—
732	θ *Librae*	15 46.7	−16 22	4.49	1	—	4.8	—	—	—
733	ρ *Scorpii*	15 49.2	−28 51	4.16	2	4.5	4.5	—	—	—
734	γ *Serpentis*	15 50.7	+16 4	3.99	1	—	3.9	—	—	—
735	*48 Librae*	15 51.2	−13 55	5.45	1	—	5.4	—	—	—
736	π *Scorpii*	15 51.3	−25 45	3.04	3	2.9	3.4	—	—	—
737	η *Lupi*	15 51.8	−38 2	3.68	3	5.0	3.7	3.9	3.7	—
738	δ *Scorpii*	15 52.9	−22 16	2.51	4	2.3	2.4	—	—	—
739	η *Normae*	15 54.0	−48 53	5.39	1	6.4	5.2	5.0	5.6	—
740	ξ *Scorpii*	15 57.5	−11 2	4.49	1	—	4.6	—	—	—
741	δ *Normae*	15 57.7	−44 50	5.35	1	5.9	4.9	5.1	5.7	—
742	β *Scorpii*	15 58.2	−19 28	2.70	3	—	2.5	—	—	—
743	θ *Lupi*	15 58.4	−36 28	4.88	2	5.0	4.9	4.7	4.8	—
744	ω^1 *Scorpii*	15 59.5	−20 20	4.19	1	4.5	4.4	—	—	—
745	ω^1 *Scorpii*	16 0.1	−20 32	4.71	1	5.0	4.6	—	—	—
746	δ *Apodis*	16 1.9	−78 22	4.62	2	5.0	4.6	4.5	4.6	4.66
747	δ *Trianguli*	16 4.1	−63 22	4.33	1	4.1	4.3	4.2	4.0	4.19
748	c^2 *Scorpii*	16 4.6	−27 36	5.05	1	5.4	5.3	—	—	—
749	υ *Scorpii*	16 4.7	−19 8	4.28	1	—	4.3	—	—	—
750	ψ *Scorpii*	16 5.2	− 9 44	5.40	1	—	5.2	—	—	—
751	χ *Scorpii*	16 6.9	−11 31	5.14	1	—	5.6	—	—	—
752	δ *Ophiuchi*	16 7.8	− 3 22	2.88	1	—	2.7	—	—	—
753	"Cluster"	16 9.6	−22 40	4.62	1	—	—	—	—	—
754	ε *Ophiuchi*	16 11.7	− 4 23	3.46	1	—	3.3	—	—	—
755	ο *Scorpii*	16 13.1	−23 52	3.76	1	5.4	5.1	—	—	—
756	σ *Scorpii*	16 13.6	−25 17	3.13	4	3.1	3.4	3.0	—	3.16
757	γ *Apodis*	16 14.3	−78 37	4.31	2	4.5	3.9	4.1	4.0	4.16
758	σ *Serpentis*	16 15 7	+ 1 19	5.60	1	—	5.4	—	—	—
759	ρ *Ophiuchi*	16 18.1	−23 9	4.80	1	5.0	4.8	—	—	—
760	υ *Ophiuchi*	16 21.0	− 8 5	5.19	1	—	5.2	—	—	—
761	α *Scorpii*	16 21.7	−26 9	1.37	9	1.3	1.4	—	—	—
762	*i Scorpii*	16 22.6	−24 50	4.54	1	5.9	5.3	5.3	—	—
763	*N Scorpii*	16 23.2	−34 26	4.50	3	5.0	4.6	4.7	4.8	—

TABLE III — *Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
764	*φ Ophiuchi*	16 24.0	−16 20	5.22	1	—	4.6	—	—	—
765	*λ Ophiuchi*	16 24.6	+ 2 16	3.89	1	—	3.8	—	—	—
766	*ω Ophiuchi*	16 24.7	−21 12	4.88	1	5.0	4.7	—	—	—
767	*β Herculis*	16 24.8	+21 46	2.92	1	—	—	—	—	—
768	*β Apodis*	16 25.3	−77 15	4.25	1	4.5	4.5	4.4	4.4	4.41
769	*τ Scorpii*	16 28.1	−27 57	3.08	4	3.1	3.2	—	—	—
770	*H Scorpii*	16 28.1	−35 0	4.58	3	5.4	4.4	4.3	4.6	var.?
771	*ζ Ophiuchi*	16 30.3	−10 19	2.71	2	—	2.6	—	—	—
772	*Lac. 6906*	16 34.1	−66 52	4.90	1	5.9	5.6	5.7	5.4	—
773	*α Trianguli*	16 35.4	−68 48	2.05	9	2.3	2.2	2.0	2.1	2.13
774	*ε Scorpii*	16 42.1	−34 4	2.40	3	2.9	2.3	2.3	2.4	2.46
775	*μ^1 Scorpii*	16 43.4	−37 50	3.41	2	3.8	3.6	3.3	3.2	3.46
776	*μ^2 Scorpii*	16 43.9	−37 48	3.91	1	4.5	3.9	3.9	3.5	—
777	*ζ^2 Scorpii*	16 45.8	−42 9	3.85	2	4.5	3.6	3.6	3.5	—
778	*ι Opiuchi*	16 48.1	+10 22	5.05	1	—	—	—	—	—
779	*κ Ophiuchi*	16 51.7	+ 9 34	3.29	1	—	3.4	—	—	—
780	*η Ophiuchi*	17 3.2	−15 34	2.58	2	—	2.4	—	—	—
781	*η Scorpii*	17 3.2	−43 4	3.45	2	3.8	3.6	3.4	3.7	3.59
782	*α Herculis*	17 8.9	+14 32	3.15	1	—	—	—	—	—
783	*o Ophiuchi*	17 10.4	−24 9	5.32	1	6.4	5.5	—	—	—
784	*θ Opihuchi*	17 14.3	−24 52	3.52	1	3.5	3.6	3.5	—	3.53
785	*β Arae*	17 14.9	−55 24	3.09	2	2.9	2.8	2.7	2.8	2.86
786	*γ Arae*	17 14.9	−56 15	3.46	2	3.5	3.6	3.5	3.4	3.49
787	*α Arae*	17 22.2	−49 46	3.08	2	2.9	2.9	2.9	3.1	2.98
788	*υ Scorpii*	17 22.3	−37 12	3.01	2	2.9	3.2	2.9	3.0	3.00
789	*λ Scorpii*	17 25.1	−37 1	1.84	6	2.0	2.0	1.9	2.2	1.99
790	*θ Scorpii*	17 28.3	−42 55	2.12	8	2.3	2.1	2.1	2.2	2.16
791	*α Ophiuchi*	17 29.1	+12 39	2.27	1	—	2.1	—	—	—
792	*ξ Serpentis*	17 30.4	−15 19	3.69	1	—	3.7	—	—	—
793	*κ Scorpii*	17 33.8	−38 58	2.69	4	2.7	2.6	2.6	2.7	2.66
794	*ι^1 Scorpii*	17 38.8	−40 4	3.15	2	3.1	3.3	3.1	3.2	3.17
795	*G Scorpii*	17 41.3	−37 0	3.37	3	3.1	3.4	3.2	3.5	3.31
796	*ν Ophiuchi*	17 52.2	− 9 45	3.01	1	—	3.5	—	—	—
797	*γ Sagittarii*	17 57.8	−30 25	3.37	1	3.1	2.8	3.0	—	—
798	*μ Sagittarii*	18 6.3	−21 5	4.22	1	3.8	4.3	—	—	—
799	*η Sagittarii*	18 9.2	−36 48	3.50	1	3.1	3.3	3.0	3.4	—
800	*δ Sagittarii*	18 13.0	−29 53	2.83	3	2.9	2.8	2.7	—	2.81
801	*η Serpentis*	18 14.8	− 2 56	3.32	1	—	3.5	—	—	—
802	*ε Sagittarii*	18 15.9	−34 26	2.07	4	2.3	2.2	2.0	2.4	2.19
803	*α Telescopii*	18 17.7	−46 2	3.78	1	4.1	3.5	3.8	3.8	3.80
804	*λ Sagittarii*	18 20.2	−25 29	2.91	2	2.9	2.7	—	—	—
805	*Ll. 34356*	18 28.1	−11 4	5.17	1	—	5.7	—	—	—
806	*ζ Pavonis*	18 28.4	−71 32	3.98	1	4.1	4.2	4.2	4.8	—
807	*α Scuti*	18 28.4	− 8 20	3.95	1	—	3.6	—	—	—
808	*α Lyrae*	18 32.7	+38 40	0.92	2	—	—	—	—	—
809	*φ Sagittarii*	18 37.8	−27 7	3.48	3	3.5	3.7	—	—	—
810	*β Scuti*	18 40.5	− 4 53	4.39	1	—	4.5	—	—	—
811	*σ Sagittarii*	18 47.5	−26 27	2.31	5	2.3	2.4	—	—	—
812	*ξ^1 Sagittarii*	18 49.9	−20 49	5.71	1	—	5.7	—	—	—
813	*θ Serpentis*	18 50.0	+ 4 3	3.78	1	—	4.2	—	—	—
814	*ξ^2 Sagittarii*	18 50.3	−21 16	3.67	2	3.8	3.5	—	—	—
815	*ε Coronae Aust*	18 50.3	−37 16	5.69	1	5.9	5.5	5.3	—	—

TABLE III.—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
816	*η Scuti*	18 50.4	— 6 0	4.78	1	—	5.4	—	—	—
817	*ζ Coronae Aust.*	18 54.3	—42 16	4.55	1	5.9	5.2	5.1	5.4	—
818	*ζ Sagittarii*	18 54.6	—30 3	2.77	3	2.9	3.1	2.7	—	—
819	*i Aquilae*	18 55.0	— 5 55	4.50	1	—	3.8	—	—	—
820	*o Sagittarii*	18 57.2	—21 55	3.97	2	4.1	3.8	—	—	—
821	*γ Coronae Aust.*	18 58.0	—37 14	4.11	1	5.0	4.6	4.5	5.0	—
822	*τ Sagittarii*	18 59.1	—27 51	3.63	2	3.8	3.6	—	—	—
823	*ζ Aquilae*	18 59.6	+13 41	3.24	1	—	—	—	—	—
824	*λ Aquilae*	18 59.6	— 5 4	3.40	1	—	3.3	—	—	—
825	*δ Coronae Aust.*	18 59.6	—40 41	4.45	1	5.4	5.0	4.7	5.1	—
826	*α Coronae Aust.*	19 1.0	—38 6	4.11	1	4.5	4.2	4.4	4.9	—
827	*β Coronae Aust.*	19 1.4	—39 32	4.11	1	4.5	4.1	4.2	4.8	—
828	*π Sagittarii*	19 2.3	—21 13	3.09	3	3.1	3.1	—	—	—
829	*d Sagittarii*	19 10.3	—19 10	5.08	1	—	5.6	—	—	—
830	*β¹ Sagittarii*	19 13.7	—44 42	3.93	1	4.5	3.8	4.3	4.1	—
831	*β² Sagittarii*	19 14.2	—45 2	4.67	1	5.0	4.4	4.6	4.3	—
832	*ρ¹ Sagittarii*	19 14.4	—18 5	4.43	2	—	4.2	—	—	—
833	*υ Sagittarii*	19 14.6	—16 11	4.94	1	—	4.9	—	—	—
834	*α Sagittarii*	19 15.2	—40 51	4.02	1	4.5	4.0	4.3	4.4	—
835	*δ Aquilae*	19 19.2	+ 2 52	3.48	1	—	3.4	—	—	—
836	*γ Aquilae*	19 40.3	+10 18	2.86	3	—	—	—	—	—
837	*Lac. 8239*	19 43.3	—40 11	5.26	1	5.9	5.6	5.8	6.0	—
838	*α Aquilae*	19 44.7	+ 8 32	1.33	4	—	1.1	—	—	—
839	*ε Pavonis*	19 46.1	—73 14	3.82	1	3.5	4.0	4.2	4.7	—
840	*η Aquilae*	19 46.1	+ 0 41	4.01	1	—	var.	—	—	var.
841	*ι Sagittarii*	19 46.6	—42 12	4.33	1	4.5	4.3	4.3	4.6	4.41
842	*ω Sagittarii*	19 48.2	—26 38	4.94	1	5.4	5.1	—	—	—
843	*β Aquilae*	19 49.2	+ 6 6	3.96	2	—	3.9	—	—	—
844	*b Sagittarii*	19 49.3	—27 30	4.94	1	5.4	4.6	—	—	—
845	*θ¹ Sagittarii*	19 51.6	—35 37	4.80	1	5.4	4.5	5.0	5.0	4.94
846	*c Sagittarii*	19 55.0	—28 0	4.94	1	5.4	4.7	—	—	—
847	*Lac. 8310*	19 55.2	—38 17	5.46	1	5.9	5.0	5.0	5.7	—
848	*δ Pavonis*	19 56.4	—66 30	3.62	1	3.5	3.5	3.6	3.4	3.52
849	*θ Aquilae*	20 4.8	— 1 11	3.40	1	—	3.0	—	—	—
850	*α¹ Capricorni*	20 10.7	—12 54	4.21	1	—	4.5	—	—	—
851	*α² Capricorni*	20 11.1	—12 56	3.53	1	—	3.6	—	—	—
852	*β Capricorni*	20 14.0	—15 10	3.10	1	—	3.1	—	—	—
853	*α Pavonis*	20 15.7	—57 8	2.13	7	2.0	2.1	2.1	2.3	2.13
854	*α Indi*	20 28.8	—47 43	3.22	4	2.9	3.1	3.2	3.3	3.14
855	*β Pavonis*	20 33.7	—66 39	3.58	2	2.9	3.3	3.6	3.3	—
856	*α Cygni*	20 37.2	+44 50	1.84	1	—	—	—	—	—
857	*β Indi*	20 45.0	—58 55	3.78	1	4.1	3.7	3.8	3.7	3.82
858	*γ Pavonis*	21 16.1	—65 56	3.63	2	4.1	4.5	4.4	4.8	var.?
859	*β Aquarii*	21 25.0	— 6 7	2.72	1	—	2.6	—	—	—
860	*ν Octantis*	21 27 5	—77 55	3.72	1	4.1	3.8	3.8	4.0	—
861	*γ Capricorni*	21 33.2	—17 13	3.58	1	—	3.7	—	—	—
862	*ι Piscis Aust.*	21 37.5	—33 36	4.43	1	5.0	4.4	4.7	4.6	—
863	*ε Pegasi*	21 38.0	+ 9 18	2.47	2	—	2.3	—	—	—
864	*δ Capricorni*	21 40.1	—16 41	2.96	1	—	2.8	—	—	—
865	*γ Gruis*	21 46.3	—37 57	3.06	7	3.1	3.0	3.2	3.3	3.13
866	*o Aquarii*	21 56.8	— 2 46	5.00	1	—	4.9	—	—	—
867	*λ Gruis*	21 58.6	—40 9	4.56	1	5.0	4.7	4.8	4.6	—
868	*α Aquarii*	21 59.4	— 0 56	2.80	1	—	2.7	—	—	—

TABLE III—*Continued.*

No.	Name	R.A.	Dec.	h.	n.	B.	U.A.	S.M.P.	W.	Mean
		h m	° ′							
869	*ι Aquarii*	21 59.7	−14 29	4.29	1	—	4.4	—	—	—
870	*α Gruis*	22 0.3	−47 34	1.70	7	1.7	1.9	2.0	2.0	—
871	*μ Piscis Aust.*	22 1.1	−33 36	4.79	1	4.5	4.7	4.9	4.6	4.70
872	*ν Piscis Aust.*	22 1.1	−34 39	5.41	1	5.0	5.4	5.3	—	—
873	*μ¹ Gruis*	22 8.1	−41 58	5.02	1	5.4	5.0	5.2	5.0	5.12
874	*α Toucani*	22 9.9	−60 53	2.98	6	2.9	2.8	2.9	2.5	2.82
875	*θ Aquarii*	22 10.2	− 8 24	4.10	1	—	4.3	—	—	—
876	*ρ Aquarii*	22 13.6	− 8 27	5.34	1	—	5.6	—	—	—
877	*γ Aquarii*	22 15.2	− 2 1	3.78	1	—	3.9	—	—	—
878	*δ Toucani*	22 18.4	−65 36	4.10	2	4.5	4.8	5.0	—	—
879	*π Aquarii*	22 18.9	+ 0 45	4.48	1	—	4.9	—	—	—
880	*δ¹ Gruis*	22 21.8	−44 8	4.16	1	4.1	4.2	4.2	4.1	4.15
881	*δ² Gruis*	22 22.3	−44 23	4.21	1	4.1	4.4	4.5	4.1	4.26
882	*ζ Aquarii*	22 22.4	− 0 40	3.69	1	—	3.5	—	—	—
883	*σ Aquarii*	22 24.0	−11 19	5.28	1	—	5.1	—	—	—
884	*β Piscis Aust*	22 24.4	−32 59	4.38	1	4.1	4.4	4.7	4.4	4.40
885	*ν Toucani*	22 24.5	−62 37	5.65	1	5.9	5.5	5.1	—	—
886	*η Aquarii*	22 28.9	− 0 46	3.93	1	—	4.1	—	—	—
887	*61 Aquarii*	22 29.1	−18 6	5.21	1	—	6.7	—	—	—
888	*β Octantis*	22 33.1	−82 2	3.93	1	5.0	4.4	4.6	4.5	—
889	*ε Piscis Aust.*	22 33.7	−27 42	4.33	1	4.1	4.3	—	—	—
890	*β Gruis*	22 35.2	−47 32	2.11	8	2.3	2.2	2.2	2.4	2.24
891	*19 Piscis Aust.*	22 35.4	−30 1	5.13	1	—	6.5	6.7	6.6	—
892	*ρ Gruis*	22 36.2	−42 4	5.12	1	5.4	5.2	5.2	5.3	5.24
893	*η Gruis*	22 37.9	−54 9	4.61	2	4.5	5.1	5.2	5.1	—
894	*ε Gruis*	22 41.0	−51 58	3.45	5	4.1	3.5	3.8	3.4	—
895	*τ Aquarii*	22 43.0	−14 15	4.06	1	—	4.2	—	—	—
896	*γ Piscis Aust.*	22 45.6	−33 32	4.66	1	4.5	4.6	4.9	4.6	4.65
897	*λ Aquarii*	22 46.1	− 8 15	3.88	1	—	3.6	—	—	—
898	*δ Aquarii*	22 48.0	−16 29	3.13	2	—	3.2	—	—	—
899	*δ Piscis Aust.*	22 49.0	−33 12	4.73	1	4.5	4.4	4.3	4.4	—
900	*α Piscis Aust.*	22 50.7	−30 17	1.49	7	1.3	1.4	1.5	1.8	—
901	*ζ Gruis*	22 53.5	−53 25	4.07	1	4.1	4.0	4.3	4.3	4.15
902	*π Piscis Aust.*	22 56.6	−35 26	5.14	1	5.4	5.3	5.4	5.5	—
903	*β Pegasi*	22 57.7	+27 24	2.62	1	—	—	—	—	—
904	*α Pegasi*	22 58.5	+14 32	2.54	1	—	—	—	—	—
905	*θ Gruis*	22 59.8	−44 12	4.12	1	4.5	4.2	4.6	4.4	—
906	*c¹ Aquarii*	23 0.0	−24 25	4.93	1	4.5	4.4	—	—	—
907	*c² Aquarii*	23 2.8	−21 51	3.71	2	3.8	3.7	—	—	—
908	*c³ Aquarii*	23 3.2	−23 8	4.86	1	5.4	4.9	—	—	—
909	*ι Gruis*	23 3.3	−45 55	3.61	2	4.1	3.9	4.2	4.2	—
910	*γ Toucani*	23 10.1	−58 55	3.89	3	4.1	4.0	4.1	—	—
911	*b¹ Aquarii*	23 16.4	−20 47	4.18	1	4.1	3.9	—	—	—
912	*b² Aquarii*	23 19.5	−21 20	4.42	1	4.5	4.4	—	—	—
913	*b³ Aquarii*	23 26.7	−21 36	4.60	1	4.5	4.5	—	—	—
914	*ι Phoenicis*	23 28.3	−43 18	4.47	1	4.5	4.4	[5.2]	4.7	—
915	*Lac. 9543*	23 32.7	−47 20	4.52	1	6.4	6.3	6.7	—	var ?
916	*δ Sculptoris*	23 42.4	−28 49	4.34	1	4.1	4.6	—	—	—
917	*η Toucani*	23 51.0	−64 59	4.82	2	5.4	5.3	5.5	4.7	var ?
918	*ε Toucani*	23 53.4	−66 16	4.48	3	5.0	4.3	4.9	4.0	—
919	*ζ Sculptoris*	23 55.9	−30 25	4.62	1	4.5	5.2	5.3	5.0	—

HONGKONG OBSERVATORY,
January 15, 1900.

ON THE DISTRIBUTION OF ENERGY IN THE SPECTRUM OF THE BLACK BODY AT HIGH TEMPERATURES.[1]

By F. PASCHEN.

I WAS able to show in a previous communication[2] that the law of radiation of the black body proposed by W. Wien is the more completely confirmed by observations, within the range of temperature from 100° to 450° C., according as the arrangement of the experiment is more closely adapted to the theoretical premises. This law has also received an important support from the theoretical researches of M. Planck.[3] He derives the law from his electro-magnetic theory of radiation, and thereby introduces only one additional hypothesis, that for the definition of Entropy, which, although not regarded by him as fully established, is, however, probably more reliable than the assumptions which led Wien to the same results based on the kinetic theory of gases. According to Planck's presentation also, the law appears to be a rigorously valid law of nature, and its contents possess a general significance.

The problem remaining for experimental investigation is, first, to investigate the limits within which the law, and hence Planck's assumptions, are found to hold good; and second, to determine the constants of the law as accurately as possible.

From the results of the investigation of the region of lower temperatures I expected to find the law to be valid within very small limits of error at higher temperatures. My experiments showed, however, that many kinds of experimental difficulties arise here.

[1] *Sitzungsberichte der Berliner Akademie.* Session of the Physical-Mathematical Section on December 7, 1899.

[2] This JOURNAL, 10, 40, 1899.

[3] "Ueber irreversible Strahlungsvorgänge." *Sitzungsberichte der Berliner Akademie*, Session of May 18, 1899, p. 440.

While at low temperatures the production of radiation by the black body appears quite simple, and only a few special adaptations of the bolometer are necessary in order that the radiation of the longer wave-length shall be sufficiently absorbed, it was comparatively difficult for me to realize the radiation of the black body so perfectly at higher temperatures that its energy curve followed the law within the limits of the errors of observation.

I attempted to produce the radiation first by cavities with heated walls, and secondly, by causing the total radiation from a small incandescent surface to be repeatedly reflected by mirrors upon the surface itself. In the first arrangement, which seems to be the better, it is extremely difficult to heat with sufficient uniformity the walls of the cavity provided with an aperture. The greater the cavity and its aperture, and the higher the temperature, so much greater will be the difference in temperature at different points of the walls. Not until these differences were reduced to a small amount did the emergent radiation exhibit the energy curve of Wien's law with a sufficient degree of approximation.

With the second arrangement,—that of producing the radiation of the black body by reflection,—it is, indeed, possible to heat a small opaque surface uniformly, but the difficulty is to make the reflection somewhere nearly complete. Even if we can only correct by this the deviation[1] of the radiation of the surface from that of the black body at the same temperature,—a difference which can be reduced to a small amount by the use of a suitable surface for the incandescent layer,—I should nevertheless have been obliged to use an expensive reflecting hemisphere. The form of the image outside of the center of a reflecting sphere introduces further an irregularity, varying with the temperature, in the incandescence of a surface which is not very small. Finally the accurate measurement of a high temperature turns out be very difficult with this arrangement.

On gradually improving the arrangement of the experiment, according to both methods, I have found that each improvement

[1] *Wied. Ann.*, **60**, 719, 1897.

reduces the amount of the departure of the results of the observations from the demands of theory, until finally results were obtained by both methods in complete agreement among themselves and also apparently in sufficient agreement with the results obtained at lower temperatures. The slight isolated deviations from the law found in the results now to be communicated are for the most part the relics of larger departures, and therefore only prove that certain defects in the arrangement were not sufficiently overcome. Should we desire to carry the accuracy of the measurements still further, however, it would be necessary to make a decided improvement in the arrangement, now only just sufficient, in order to establish the validity of the law within still smaller limits of error.

As it would lead us too far aside, if I were to detail all the researches which I have made in order to surmount the difficulties of a purely practical nature, I shall limit myself to the communication of the results obtained with the most suitable arrangements employed for the purpose.

The general arrangement of the spectroscopic apparatus remained the same as for the investigation at lower temperatures. In all the measures at high temperatures the exposed bolometer filament consisted of a strip of platinum 4 mm long, 0.3 mm wide, and $\frac{1}{2000}$ mm thick, which was covered with a thick layer of platinum black, and was placed at the center of the reflecting hemisphere previously described. The current in the bolometer was always maintained at the same strength, and the sensitiveness of the apparatus to radiation was varied by the introduction of resistances in the circuit of the galvonometer.

The temperature was always measured with a thermo-element of wires of platinum and platinum-rhodium of 0.15 mm diameter, which Mr. Holborn had kindly calibrated for me in 1898. All temperatures above 450° C. correspond to this calibration, but lower temperatures correspond to the scale of two mercury thermometers which had been certified by the *Reichsanstalt*. The thermo-electromotive forces were measured by compensation.

In measuring up an energy spectrum at those places where the energy rapidly changed (at small wave-lengths) I proceeded by steps of the apparent breadth of the bolometer strip (3′), in order to be able to accurately apply the correction for the impurity of the spectrum caused by the width of the bolometer strip and the equally wide slit. In the remaining part of the spectrum I selected a few places as free as possible from absorption and uniformly distributed. Along with the energy curve thus more completely observed I made check measurements at the same temperatures, determining the throw of the galvanometer at only eight or ten places, uniformly distributed in the spectrum. These served as a check on the more complete energy curves and for the most part they are not given in the tables.

The observations were at first compared with the theory in the same way as in my paper on lower temperatures. For this purpose the observed values of the wave-length λ_m and of the intensity J_m of the maximum of the energy curve were given in tables, and the relations obtained for these constants were tested, *viz.*:

I. $\lambda_m \cdot T = \text{constant}.$

II. $J_m / T^5 = \text{constant}.$[1]

In case the observed energy-curve differs appreciably from the theoretical requirement, *viz*:

III. $$J/J_m = \left\{ \frac{\lambda_m}{\lambda} e^{\frac{\lambda - \lambda_m}{\lambda}} \right\}^5,$$

this is indicated in a remark. In order to show how far the observed energy-curve follows this law, the observed points of

[1] In the determination of the values λ_m and J_m from an energy curve, all of the observed points of the curve are always employed, so that, $\lambda_m \cdot T = \text{constant}$ at the same time expresses the fact that each wave-length is so displaced that the relationship $\lambda \cdot T = \text{constant}$ is also fulfilled. In case relation II holds, the intensities of the wave-lengths therefore corresponding with each other are further proportional to T^5 (Wien's general law). The energy curves at different temperatures, expressed in logarithmic measure (with log J for ordinates and log λ for abscissas) are accordingly congruent, or J/J_m is the same function of λ/λ_m at all temperatures. This relation, together with I and II above, is identical with the relations as formulated by Wien.

different energy-curves are represented in a figure, along with the theoretical curve III. If the three conditions I, II, and III are fulfilled, Wien's general formula

IV. $$J = c_1 \lambda^{-5} e^{-\frac{c_2}{\lambda T}}$$

is established. A more rigorous mode of investigating the law will be given in my conclusion.

I. MEASUREMENTS ON CAVITIES WITH HEATED WALLS.

A cavity of unglazed porcelain was made in the manner described by Lummer and Kurlbaum.[1] A porcelain cylinder of 5 cm diameter and 10 cm length having six cross walls was made in one piece. The length of the central radiating cavity was 5 cm, and it had two chambers both before and behind it. The apertures of the three walls in front had an area 0.6 sq. cm. A cylinder of platinum foil was wrapped around the porcelain cylinder, and was heated by an electric current. The radiating body was surrounded by an air space and by an asbestos covering. The losses of heat by conduction, chiefly due to the apertures, cause a lack of uniformity in the temperature of the walls of the cavity. The wall of the cylinder is hotter than the rear wall, and this again is hotter than the front wall, which is especially cooled off in the immediate neighborhood of the aperture. Without a protecting cover, the upper half of the radiating body is hotter than the lower half, in consequence of the rising warm air, and those parts of the platinum foil which are in contact with the porcelain differ from those which are not in contact. These irregularities increase with rising temperature, and further depend upon the external protection of the radiating body and upon the diaphragms placed in front of the aperture.

The thermo-element was introduced through the rear cross walls, and measured the temperature of the radiating part of the rear wall. As soon as the incandescent body has reached a stationary condition, the thermo-element almost completely vanishes in the background, even if very considerable difference in

[1] *Ber. der Phys. Gesellschaft zu Berlin*, **17**, 106, 1898.

the temperature occur in the walls,—which may probably be explained by the near equality in the reflecting power for visible rays of the metal wires and of the porcelain.

In the three following series of measures the cavity was differently protected, and the light coming from the aperture was differently diaphragmed. For a given series the arrangement was kept as nearly as possible the same.

LARGE PORCELAIN CAVITY.

TABLE I

Temperature C.	Temperature Abs.	λ_m (μ)	$\lambda_m T$	J_m	$J_m/T^5 \times 10^{15}$	
413°.7	686°.5	4.222	2899	0.5420	3.553	
443.2	716.2	4.057	2905	0.6740	3.578	
643.8	916.8	3.199	2933	2.320	3.582	
693.0	966.0	3.044	2941	3.041	5.612	
907.3	1180.3	2.492	2941	8.464	3.695	Ch.[1]
933.0	1206.0	2.437	2940	8.560	3.764	
1048.1	1321.1	2.233	2950	15.03	3.737	Ch.
1053.4	1326.4	2.219	2945	15.65	3.807	
			Mean 2932	m. e. = 5		

TABLE II

411°.6	684°.6	4.235	2899	0.5114	3.398	
692.8	965.8	3.033	2928	2.855	3.397	
865.5	1138.5	2.556	2911	6.483	3.383	At the longest wave-lengths higher than the theoretical curve.
871.2	1144.2	2.575	2946	6.635	3.389	
958.2	1231.2	2.381	2931	9.528	3.370	Ch. Fits the theoretical curve poorly.
			Mean 2923	m. e. = 8		

TABLE III

374°.1	647°.2	4.508	2917	0.5419	4.774	Ch.
377.3	650.3	4.446	2889	0.5543	4.767	
654.0	927.0	3.155	2925	3.265	4.768	Ch.
664.6	937.6	3.113	2919	3.513	4.850	
845.2	1118.2	2.610	2918	8.534	4.888	
1043.4	1316.4	2.218	2921	18.79	4.741	Inaccurate on account of unsteady temperature.
			Mean 2915	m. e. = 5		

[1] Ch. denotes a check measure as distinguished from the more complete measures.

The third of this series may probably be regarded as the best in respect to arrangement. The differences in the values of $\lambda_m \cdot T$ and J_m / T^5 are larger in series I than would be expected from the residuals.

In order to obtain a more uniform temperature of the cavity, I selected the arrangement sketched in Fig. 1 *a* and *b*. A metallic crucible *T* (of copper or platinum), with thick walls,

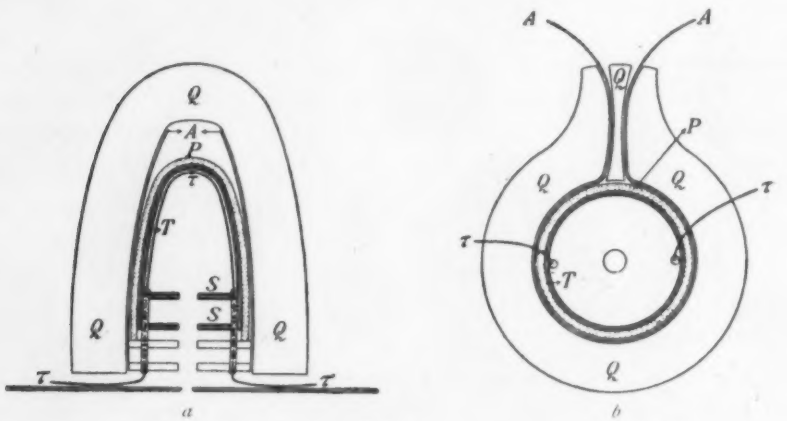

FIG. 1.

was separated into two chambers by two round separating walls *S*, of the same metal, with small round apertures. The rear chamber was the radiating cavity. A porcelain crucible *P*, with very thin walls, surrounded the metallic crucible. For the electric heating of the space I wrapped about this, as may be seen from the drawing, the platinum foil *A* which projected out from in front and from behind. *Q* was an asbestos cover. Two or three cross walls of asbestos were also attached. The length of the cavity amounted to about 3.5 cm, with an extreme breadth of 3 cm. The round apertures in *S* had a diameter of about 5 mm. As a result of the good conductivity in the metallic wall, and of the small dimensions of the cavity, a pretty uniform temperature was obtained in the interior of the cavity. The thermo-element *T* was introduced from in front through a thin small tube of porcelain. When the inner surface of the wall

was composed of metallic oxides (of copper or iron) the thermo-element did not disappear in the background unless the temperature of the cavity was practically uniform throughout, since the reflection of the visible rays was very different from the platinum wires and from the metallic oxides. It appeared dark on a bright ground when the metallic walls S were cooler than the back part of the crucible, and bright on a dark ground when they were warmer. The temperature distribution in the cavity could, however, be altered according to the mode of the external wrapping with asbestos, and it was possible to regulate this in such a way that the thermo-element almost entirely disappeared.[1]

If the interior metal wall was surrounded with porcelain, however, this appearance ceased to give a sensitive mode of judging of the inequalities of temperature in the cavity.

First arrangement. The metal crucible was of copper, which oxidized on incandescence in the air, and was almost entirely converted into oxide at the close of the experiment.

TABLE IV

Temperature		λ_m	$\lambda_m \cdot T$	J_m	$J_m/T^5 \times 10^{15}$	
C.	Abs.					
560°.0	833°.0	3.482	2900	1.583	3.946	
885.3	1158.3	2.525	2925	8.410	4.035	
501°.2	774°.2	3.748	2901	0.8532	3.069	Apertures smaller.
685.2	958.2	3.067	2939	2.464	3.050	
878.7	1171.7	2.502	2931	6.669	3.021	
			Mean 2919	m. e. = 8		

Second arrangement. The metal crucible was of platinum. The inner surface of the cavity was covered with a thin wall of porcelain. (A second porcelain crucible was fitted into the platinum crucible. The front cross wall of the cavity consisted of porcelain on the inside and platinum on the outside.)

[1] The wires could no longer be seen by an observer who did not know their location.

TABLE V

Temperature C.	Temperature Abs.	λ_m	$\lambda_m \cdot T$	J_m	$J_m/T^5 \times 10^{15}$	
411°.1	684°.1	4.212	2882	0.2015	1.344	Ch.
731.6	1004.6	2.896	2910	1.380	1.349	
732.0	1005.0	2.891	2904	1.394	1.360	Ch.
733.7	1006.7	2.884	2903	1.401	1.355	Ch.
1029.1	1302.1	2.233	2908	5.286	1.413	Ch.
1035.7	1308.7	2.223	2910	5.237	1.363	
1044.3	1317.3	2.217	2920	5.534	1.396	Ch.
1283.9	1556.9	1.887	2939	12.80	1.399	
			Mean 2910	m. e. = 6		

Third arrangement. The platinum crucible of the previous arrangement was covered with iron oxide after the removal of the porcelain wall.

TABLE VI a

Temperature C.	Temperature Abs.	λ_m	$\lambda_m \cdot T$	J_m	$J_m/T^5 \times 10^{15}$	
743°.0	1016°.0	2.858	2899	1.514	1.398	
1060.5	1333.5	2.188	2917	5.984	1.419	
467.6	740.6	3.864	2862	0.3221	1.446	
500.6	773.6	3.713	2873	0.4042	1.458	Ch.
687.4	960.4	3.010	2891	1.208	1.478	
731.4	1004.4	2.865	2878	1.507	1.474	Ch.
951.4	1224.4	2.367	2898	4.134	1.503	
961.2	1234.2	2.357	2908	4.331	1.508	Ch.
979.5	1252.5	2.310	2893	4.578	1.484	
982.0	1255.0	2.312	2902	4.639	1.489	Ch.
1294.3	1567.3	1.849	2898	14.39	1.523	At long wave-lengths deviations from the theoretical curve occur.
423.2	696.2	4.153	2891	0.4088	2.501	
737.5	1010.5	2.861	2891	2.795	2.655	
762.5	1035.5	2.791	2890	3.235	2.719	
791.6	1064.6	2.721	2897	3.632	2.655	The observed points lie above the theoretical curve at both ends of the curve.
1008.4	1281.4	2.271	2909	9.438	2.734	
1221.	1494.	1.967	2941	20.08	2.690	The curve is too high at the longer wave-lengths.
			Mean 2896	m. e. = 4		

The platinum crucible was freshly covered with iron oxide; aperture very small and incandescence very uniform.

TABLE VI b

Temperature C.	Temperature Abs.	λ_m	$\lambda_m \cdot T$	J_m	$J_m/T^5 \times 10^{15}$	
701°.4	974°.4	2.960	2886	1.726	1.963	Ch.
706.3	979.3	2.951	2890	1.767	1.961	
992.7	1265.7	2.286	2893	6.557	2.011	
995.6	1268.6	2.282	2895	6.647	2.023	Ch.
1019.7	1292.7	2.246	2905	6.920	1.915	Ch.
1259.4	1532.4	1.907	2921	16.62	1.966	Ch.
1260.3	1533.3	1.906	2921	16.79	1.981	
			Mean 2901	m. e. = 5		

II. MEASUREMENTS OF THE RADIATION OF THE BLACK BODY BY THE METHOD OF REFLECTION.

The following arrangement of the incandescent body was chosen for the experiments now to be described (Fig. 2, *a*, *b*, *c*). The radiating sheet of platinum *P*, of 0.05 mm thickness, and of about 30 mm length and 16 mm width, and two shorter sheets of platinum *S*, insulated by mica *G*, are wrapped about a strip of platinum foil or platinum-iridium foil *A*, which heats *P* and *S*, being itself heated by an electric current. The thermo-element *T* is insulated by mica from the sheet *S* and from the parts of *P* furthest from the middle, and touches *P* with the junction from the inside, that is, is attached with the junction at the middle of *P*.[1]

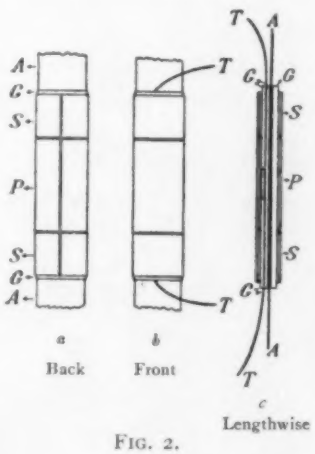

FIG. 2.

The piece *P* becomes uniformly incandescent as soon as a high temperature has been once suddenly produced, at which the water present in the mica quickly vaporizes and thereby

[1] In some of the experiments the junction was situated in the exterior surface, so that the conducting wires, insulated by a coating of iron oxide, passed through *P*; or the ends of the thermo-element which were not soldered together were allowed to touch *P* from within. The indications of temperature up to 800° C. were almost the same in all these arrangements.

uniformly inflates the strip of platinum P. The front surface of P was so adjusted in the central plane of a reflecting hemisphere that it was covered as closely as possible by its reflected image. The reflecting surface had a diameter of 15 cm and consisted of German silver; it had a good spherical figure and was admirably polished. It had a small aperture toward the incandescent surface P through which the radiation fell on the slit. The dimensions of the incandescent surface P are larger than was necessary to fill the diaphragm in front of the prism of the spectroscopic apparatus, on account of the imperfections of the image. The radiation from a portion of P only about 10 mm × 20 mm reaches the bolometer. In so far as the radiation of this smaller surface is reflected on neighboring parts of P and not on the surface itself, in consequence of the imperfections of the image, the radiation of these neighboring portions does, nevertheless, fall back upon the central portion. With a uniform incandescence of P this arrangement is accordingly equivalent to that in which the small surface only is present, and receives its own radiation completely returned upon itself.

First arrangements (for lower temperatures). The radiating sheet of metal is covered with platinum black. A bolometer strip 6′ wide is employed in the reflecting hemisphere. (See my paper on lower temperatures).

TABLE VII

Temperature		λ_m	$\lambda_m \cdot T$	J_m	$J_m / T^5 \times 10^{14}$	
C.	Abs.					
99°.9	372°.9	7.730	2883	0.2737	3.797	
186.9	459.9	6.251	2875	0.7805	3.793	
190.7	463.7	6.211	2880	0.8136	3.797	
192.1	465.1	6.194	2883	0.8248	3.788	Larger deviations [1]
313.2	586.2	4.926	2887	2.620	3.787	
316.7	589.7	4.899	2890	2.683	3.761	
318.8	591.8	4.881	2889	2.730	3.760	
453.6	726.6	3.985	2896	7.642	3.773	
599.4	872.4	3.327	2902	18.93	3.747	
603.2	876.2	3.312	2901	19.56	3.787	Higher at the ends than the theoretical curve [1]
618.3	891.3	3.252	2899	21.30	3.760	
624.1	897.1	3.232	2900	21.93	3.773	Somewhat too high at the ends [1]
			Mean 2890	m. e. = 3		

[1] At the higher temperatures the sheet is somewhat irregular in its incandescence.

Second arrangement. The bolometer strip of 6′ breadth is replaced by one of 3′. The radiating body is the same as in the first arrangement.

TABLE VIIIa

Temperature C.	Temperature Abs.	λ_m	$\lambda_m \cdot T$	J_m	$J_m / T^5 \times 10^{15}$
387°.0	660°.0	4.380	2891	0.5923	4.742
400.8	673.8	4.290	2891	0.6591	4.742
418.7	691.7	4.178	2890	0.7498	4.756
419.1	692.1	4.176	2891	0.7647	4.780
549.1	822.1	3.531	2904	1.783	4.743
557.3	830.3	3.495	2912	1.875	4.753
574.9	847.9	3.424	2903	2.095	4.779
633.5	906.5	3.214	2913	2.926	4.781
			Mean 2899	m. e. = 3.5	

Third arrangement. The platinum strip is covered with oxide of copper.

TABLE VIIIb

Temperature C.	Temperature Abs.	λ_m	$\lambda_m \cdot T$	J_m	$J_m / T^5 \times 10^{15}$
560°.5	833°.5	3.488	2907	1.907	4.737
643.1	916.1	3.174	2908	3.095	4.797
656.9	929.9	3.126	2907	3.331	4.792
737.8	1010.8	2.877	2908	5.089	4.827
848.	1121.	2.596	2908	8.494	4.799
861.	1134.	2.559	2901	8.874	4.732
			Mean 2906	m. e. = 1	

The following measurements were obtained with a somewhat different adjustment of the radiating body and of the bolometer, and with a sheet of platinum P which was not uniformly incandescent in the reflecting sphere:

Temperature C.	Temperature Abs.	λ_m	$\lambda_m \cdot T$	J_m	$J_m / T^5 \times 10^{15}$	
387°.2	660°.2	4.367	2883	0.6084	4.856	
646.6	919.6	3.159	2905	3.196	4.859	Observed curve is too high at the ends.
868.2	1141.2	2.565	2926	9.454	4.882	Observed curve is too high at the ends.

A strip covered with iron oxide and uniformly incandescent gave:

Temperature		λ_m	$\lambda_m \cdot T$	J_m	$J_m/T^5 \times 10^{15}$	
C.	Abs.					
756°.5	1029°.5	2.817	2900	5.655	4.891	

It is very difficult to obtain a uniform incandescence of a larger surface at the higher temperatures with the arrangement described, if an image of the surface itself is reflected upon itself by the hemisphere. The central parts of the surface receive a greater amount of reflected radiation, and are better protected from loss of heat than the edges. I have obtained a fairly uniform condition of incandescence in the reflecting envelope with a surface 10 mm wide of platinum 0.1 mm thick, when the back side of the strip was protected from loss of heat by a cover of mica or asbestos. Outside of the center of the reflecting sphere the strip is then less incandescent than at the edge, and if its image is projected upon itself it will be uniformly incandescent at one definite temperature only. The strip to which the following results refer was most uniformly incandescent at about 1000° C. With this arrangement I could no longer obtain a reliable determination of the temperature with the thermo-element, since the mica insulation of the wires is insufficient at 1000°. For one set of energy curves I have determined the temperatures which seem to satisfy most closely laws I and II. The curves had very nearly the shape demanded by theory.

Fourth arrangement. A surface of 10 × 25 mm, blackened with iron oxide; the diaphragm in front of the prism smaller.

TABLE IX

Abs. Temp. assumed	λ_m (obs.)	$\lambda_m \cdot T$	J_m (obs.)	$J_m/T^5 \times 10^{15}$	
834°.9	3°.468	2895	1.134	2.796	
1014.	2.862	2900	3.015	2.821	
1021.5	2.835	2896	3.129	2.815	
1273.	2.280	2903	9.478	2.833	The last end of the curve at long wave-lengths is a little too high.
1496.	1.945	2910	21.47	2.866	

It should be further mentioned that measurements, showing tolerable agreement with the experiments described and with the law, were made with a reflecting hemisphere of bronze, and with a different arrangement of the incandescent strip of platinum. As the arrangement was, however, defective in many respects,

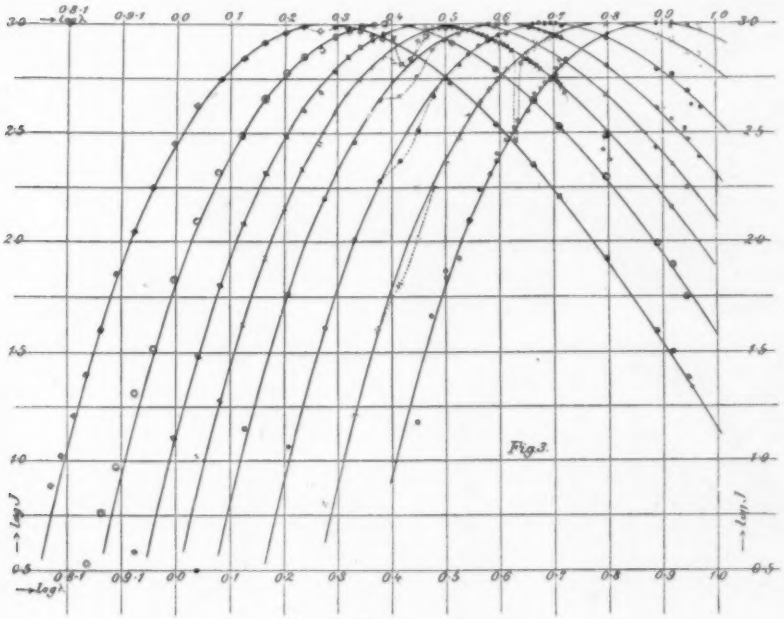

FIG. 3.

these measures need not be taken into consideration in comparison with those described.

It follows from the preceding results that the relations I and II have been found to hold good with a pretty close degree of approximation with most of the arrangements described. Somewhat larger deviations do indeed occur in a few of the series.

The observed points of a series of energy curves are represented with log J as ordinate and log λ as abscissa, in Fig. 3, and their symbols are given in the following list. For convenience of inspection log J_m is made the same in all the curves.

LIST OF THE ENERGY CURVES REPRESENTED IN FIG. 3.

Temp. C	λ_m	log λ_m	Table	Symbol
99°.9	7.730	0.8882	VII	⊙ ⊙ ⊙
190.7	6.211	0.7932	VII	× × ×
318.8	4.881	0.6885	VII	• • •
453.6	3.985	0.6004	VII	◈ ⊞ ⊡
574.9	3.424	0.5345	VIIIa	⊡ ⊡ ⊡
706.3	2.951	0.4700	VI	⊙ ⊙ ⊙
933.0	2.437	0.3869	I	◎ ◎ ◎
1283.9	1.887	0.2758	V	⊕ ⊕ ⊕

These curves teach first the validity of the proposition that all energy curves represented logarithmically are congruent, and second, that law III holds good, as the observed points very closely follow its curve indicated by the dotted line. Consequently law IV appears to be confirmed in all its parts by the observations. A more rigorous test of the validity of the law can be obtained as follows:

If we write law IV in the form

IVa. $$\log (J \,.\, \lambda^5) = \log c_1 - c_2 \,.\, \log e \frac{1}{\lambda \,.\, T},$$

the test of law IV may be reduced to that of a straight line, if we lay off $\log (J.\lambda^5)$ and consider it as a function of $\frac{1}{\lambda T}$. The form of an energy curve $\left(\frac{1}{T} = \text{constant}\right)$ is hereby reduced to that of a straight line in the same way as in the case of an isochromatic line $\left(\frac{1}{\lambda} = \text{constant}\right)$ for which I had previously adopted this mode of representation. I gave in Table X the observed values of $\log (J\lambda^5)$ for a series of check measurements[1] which were made (1) with the reflecting hemisphere (copper oxide, Table VIIIb; or platinum black, Table VIIIa; designated in Table X by *CuO* or *Pt*); (2) with the platinum crucible cavity, which was covered with iron oxide[2] Table VI;

[1] These check measures were mostly made in connection with the measurements of the complete energy curves, the results of which are given in the proper tables. All the measures were made at exactly the same wave-lengths.

[2] All of the intensities J observed with this arrangement have been multiplied by the factor 2.421, in order that they may be comparable with the intensities with the other arrangements. The factor is the ratio of the values of J_m/T^5 in Tables VI and VIII.

TABLE X.

	Abs. T	$1/T$ \ λ (μ) / $1/\lambda$	0.9104	1.208	1.589	1.971	2.316	3.247[1]	3.910	4.588	5.124[2]	6.263	7.736	8.244	Energy curves	
		0.00	1.0983	0.8278	0.6294	0.5073	0.4318	0.3080	0.25574	0.21797	0.19517	0.15967	0.12927	0.12131	C_1	C_2
H	1532.4	06526	0.618	1.742	2.562	3.060	3.373	3.891	4.115	4.280	4.374	4.524	4.663	. . .	150300	14600
			−25	−14	−11	−15	−12	−3	+4	+15	+14	+17	+31			
H	1292.7	07735	0.814−1	1.098	2.078	2.669	3.035	3.641	3.898	4.089	4.203	4.379	4.542	. . .	142200	14520
			+11	−26	−14	−18	−21	−20	−18	−12	−8	−6	+8			
H	1268.6	07883	0.718−1	1.064	2.050	2.649	3.025	3.642	3.904	4.098	4.214	4.377	4.542	. . .	147900	14480
			+17	+18	+17	+7	+8	+10	+11	+17	+20	+6	+20			
CuO	1134	08818	0.062−1	0.561	1.646	2.330	2.756	3.449	3.742	3.960	4.088	4.267	4.473	4.456	140900	14420
			+10	+4	−16	−11	−5	−3	+1	+8	+15	−9	+28	+27		
CuO	1121	08921	0.042−1	0.499	1.614	2.304	2.729	3.431	3.727	3.944	4.072	4.276	4.470	4.511	144400	14510
			+60	−15	−8	−4	−4	0	+2	+7	+6	+10	+33	+29		
CuO	1010.8	09893	. . .	0.986−1	1.232	1.992	2.472	3.250	3.580	3.820	3.960	4.186	4.373	4.417	148100	14540
				−11	−3	−6	+4	+9	+12	+16	+13	+18	+15	+10		
H	974.4	10263	. . .	0.835−1	1.101	1.876	2.362	3.158	3.493	3.740	3.884	4.119	4.326	. . .	148900	14540
				+34	+16	−2	−6	−11	−15	−14	−16	−11	−2			
CuO	929.9	10754	. . .	0.546−1	0.894	1.718	2.236	3.078	3.434	3.695	3.847	4.093	4.302	4.352	147600	14530
				−1	0	−4	+2	+4	+5	+9	+7	+12	+14	+11		
CuO	916.1	10916	. . .	0.469−1	0.842	1.664	2.190	3.043	3.409	3.671	3.825	4.074	4.278	4.323	148000	14540
				+7	+13	−5	0	0	+6	+9	+5	+10	+4	−5		
Pt	906.5	11031	. . .	0.407−1	0.783	1.626	2.156	3.023	3.390	3.655	3.810	4.063	4.280	4.347	148900	14570
				+4	−1	−6	−2	+3	+6	+8	+4	+10	+15	+27		
Pt	847.9	11794	. . .	0.011−1	0.482	1.386	1.947	2.874	3.264	3.545	3.712	3.977	4.199	4.255	146100	14510
				+8	+2	−2	−4	+2	+3	+3	0	0	−3	−6		
CuO	833.5	11997	. . .	0.872−2	0.395	1.307	1.890	2.830	3.227	3.514	3.683	3.955	4.179	4.239	145900	14530
				−24	−3	−16	−5	−2	−1	0	−4	−1	−6	−7		
Pt	830.3	12044	. . .	0.892−2	0.373	1.294	1.873	2.824	3.223	3.510	3.681	3.950	4.186	4.234	147700	14560
				+19	−8	−14	−9	0	+2	+2	0	−1	+4	−9		
Pt	822.1	12164	. . .	0.849−2	0.336	1.265	1.845	2.799	3.204	3.497	3.664	3.936	4.174	4.220	145400	14520
				+38	+3	−5	−5	0	+3	+6	−2	−2	+2	−12		
Pt	692.1	14449	. . .	. . .	0.453−1	0.558	1.231	2.363	2.836	3.176	3.383	3.708	3.971	4.050	143200	14450
					+26	+19	+4	+6	+3	−1	−2	0	−14	−8		
Pt	673.8	14841	. . .	. . .	0.283−1	0.414	1.118	2.282	2.771	3.116	3.332	3.647	3.943	4.009	142200	14460
					+14	+1	−1	+2	+2	−7	−5	−22	−10	+15		
Pt	660.0	15152	. . .	. . .	. . .	0.334	1.046	2.223	2.717	3.073	3.287	3.629	3.908	3.995	142200	14450
						+21	+11	+3	−1	−7	−11	−8	−20	−14		
Isochromatic curves		C_1	103200	138100	141100	141200	141500	144700	148500	147700	148900	145600	154800	146300		
		C_2	14100	14460	14470	14480	14500	14500	14580	14550	14580	14510	14860	14660		

	Mean values		
	Formula IVa	Energy curves	Isochromatic curves
C_1	146030	145870	145300
C_2	14531	14514	14520

[1] At this wave-length an absorption averaging 2 per cent. is corrected by a constant factor 1.020.

[2] All the intensities J observed with this arrangement have been multiplied by 2.421 to render them comparable with the intensities with the other arrangement. This factor is the ratio of the values J_m/T^5 in Table VI and Table VIII.

designated in Table X by large H). The numbers below give the difference, in units of the third decimal, of the observed values, and computed according to formula IV a (O.–C.) The following values of the constants were employed in the computation:

$$c_1 = 146030$$
$$c_2 = 14531$$

The numbers of the horizontal row represent an energy curve, which calculated as such, yield the constants printed at the right. The numbers in the vertical column represent an isochromatic curve, which calculated as such yields the constants printed below. We can, of course, locate each individual series within small limits of error on the corresponding straight line in the same manner as we may all of the numbers of all of the series of the comprehensive formula. But even the differences outstanding in this case correspond for the most part to only a few per cent. in the value of $J\lambda^5$. A deviation of 4, 9, 13, 17, 21, 25, etc., units of the third decimal correspond to 1, 2, 3, 4, 5, 6, etc., per cent. in the value of $J\lambda^5$. Within these limits of error the law is in any case demonstrated by this calculation.

TABLE XI

Abs. T.	λ (μ) / $1/\lambda$ / $1/T$ 0.00	7.738 0.12924	6.263 0.15967	4.663 0.21444	3.354 0.2982	2.279 0.4389	1.887 0.5300	Energy curves C_1	Energy curves C_2
723°0[1]	1383	4.684	4.422	3.939	3.207	1.993	1.206	634600	14450
		+4	+6	−1	−7	−1	0		
577.1	1733	4.394	4.066	3.468	2.559	1.021	0.047	636700	14465
		−2	+1	−2	0	−7	+9		
462.4	2162	4.042	3.631	2.892	1.758	0.847−1		634100	14445
		−5	−3	+1	+4	+4			
373.0	2681	3.627	3.116	2.190	0.783			633100	14445
		0	+1	−3	−1				
Isochromatic curves[2] C_1		629600	642900	630300	623000	633700	600000[3]		
Isochromatic curves[2] C_2		14440	14490	14450	14430	14460	14370		

[1] The wave-lengths belonging to this temperature were: 7.740μ, 6.264, 4.664, 3.356, 2.2181, 1889μ, and are calculated with these values.

[2] The isochromatic curves are here calculated on the basis of equal weight for all observations, (as in the computation of Formula IVa). Different weights were assigned in the earlier calculations.

[3] By an oversight the value 738800 was previously given at this point.

	Formula IVa	Mean values: Energy curves	Mean values: Isochromatic curves
C_1 - -	633000	634600	631900
C_2 - - -	14450	14450	14450

To facilitate comparison with the results at the lower temperatures I have calculated the set of observed numbers[1] previously communicated in the same manner, and give them in Table XI. We see that these observations yield a still closer validity of the law, as was to be expected from the theoretically better arrangement of the experiments.

Wien's law may accordingly be regarded as demonstrated as well as the difficulties of the experiments admit, within the range of wave-length from 9.2μ to 0.7μ (and in the research carried on in conjunction with Wanner,[2] to 0.5μ), and within the range of temperature from 1300° C. to 100° C.[3]

I consider the determination of the constant c_2 of the law as the final object of my researches. For lower temperatures I determined its value from experiments on cavities as $14455\mu \times$ degree of the absolute or of the Celsius scale.

From the radiation at lower temperatures produced by reflection Table VII gives

$c_2 = 5 \times \lambda_m \,.\, T = 5 \times 2890 = 14450$ with a mean error $= 15$.

The following value is yielded by the observations now communicated at higher temperatures. We have found as mean values of $\lambda_m \,.\, T$:

	Cavities: Table I	II	III	IV	V	VIa	VIb
$\lambda_m \,.\, T$	= 2932	2923	2915	2919	2910	2896	2901
Mean error =	4	8	5	8	6	4	5

	Reflection: Table VIIIa	VIIIb
$\lambda_m \,.\, T$	= 2899	2907
Mean error =	3.5	1

[1] Paper on lower temperatures. [2] This JOURNAL, **9**, 300, 1899.

[3] Since in the observations of lower temperatures the radiation of the space in front of the slit contributes a considerable amount with the slide let down, which amount is added to the observed intensity, the lower temperature limit is the more correct.

This mean is

	$\lambda_m \cdot T$	$c_2 = 5 \times \lambda_m \cdot T$
with equal weights of all values -	2911	14555
with the omission of the values which seem least reliable in Tables I and II	2907	14535

The last value is in accord with that on which the calculation in Table X is based, *viz.*, $c_2 = 14531$.

The results of individual series deviating most from the means are, omitting Tables I and II:

Table	Temp. C.	$\lambda_m \cdot T$	$c_2 = 5 \times \lambda_m \cdot T$
VIa -	467.6	2862	14310
VIa -	- 1221	2941	14705

I estimate the highest possible error of the mean value of $\lambda_m \cdot T$ to be 16; and hence that of c_2 to be 80.

A somewhat larger value is therefore obtained from the experiments at higher temperatures than from those at lower temperatures. We shall not be disposed to attach an excessive weight to the values of the constant c_2 found at higher temperatures when we consider the great experimental difficulties at high temperatures, and in particular the rather imperfect arrangement for producing the radiation, and further the still considerable uncertainties which seem to be possible in the determination of higher temperatures, according to the experiments of Holborn, Wien, and others. In my opinion the value $c_2 = 14455$ found with lower temperatures and relatively perfect arrangements is to be regarded as the more reliable,[1] similarly to the case of the determination of the constants of the law of total radiation for which a precise arrangement at low temperatures is preferred.

[1] I do not give a comparison of my results with those published by O. Lummer and E. Pringsheim (*Verhandlungen der Deutschen Physikalischen Gesellschaft*, 1, No. 1). as it was indicated in an address by Herr Pringsheim at the last meeting of the German Scientists' Association that the measurements are still being continued.

THE VARIABLE VELOCITY OF ϵ *LEONIS* IN THE LINE OF SIGHT.

By W. S. ADAMS.

I WISH to call attention to the evident variation in the radial velocity of ϵ *Leonis*, a third magnitude star of Type II a. Three spectrograms taken with the Yerkes refractor in February and the first part of March gave velocities of $+10.4$, $+1.2$, and -1.5 kilometers, respectively. As a range of four kilometers is considered extreme in measures of a star of this type with the dispersion and the camera employed, it was apparent that the velocity varied, and subsequent plates confirmed this variation. Fifteen plates have been secured, the results of which are as follows:

1900,	Feb.	11	+10.4 km	1900,	March	30	−1.0 km
	"	26	+1.2		"	31	−5.9
	March	6	−1.5		April	2	−1.8
	"	9	−3.0		"	3	−5.7
	"	22	−10.6		"	6	+3.0
	"	23–15 h	−3.4		"	7	−12.9
	"	23–19 h	−0.2		"	9	−0.1
	"	26	+3.6				

The total range given by these observations is 23.3 km, and the period is apparently very short, probably in the neighborhood of two and a quarter days.

All of these plates were obtained with the Brashear three-prism spectrograph attached to the 40-inch refractor and with a camera of 456 mm focal length. For a comparison spectrum the titanium spark was employed, which gives in the region measured (λ 4450–4650) a remarkably large number of fine sharp lines, well adapted to close measurement and conveniently spaced for the application of the Cornu-Hartmann interpolation formula. The measures upon the plates have been made in both directions, but no systematic variations have been detected between the values obtained with red to right and red to left.

The probable errors of the measures of course vary greatly with the quality of the two spectra and the number of lines suitable for measurement. The average probable error for the series is about ± 0.30 km: the two most critical plates, those of February 11 and April 7, give ± 0.18 km and ± 0.23 km for 15 lines and 11 lines, respectively. It should, however, of course be noted that the probable error is of value mainly as evidence of the consistency of the measures, and not as the probable limit of error in the result obtained for a given plate. This is due to the fact that systematic errors even under the best conditions enter to such an extent as to considerably outweigh it.

In view of the apparent short period of the velocity variation it would seem probable that ϵ *Leonis* is a comparatively close system, and hence peculiarly subject both to tidal disturbances and to the perturbations caused by the flattening of the components, and already noted by Tisserand and Bélopolsky in the cases of *Algol* and α^1 *Geminorum*.

YERKES OBSERVATORY,
April 17, 1900.

THE CURVATURE OF THE SPECTRAL LINES IN THE SPECTROHELIOGRAPH.

By W. S. ADAMS.

WHEN the new spectroheliograph of the Yerkes Observatory was designed the question of the curvature of the spectral lines became of great importance as determining the form of the slits to be used in correcting the distortion of the solar image. That this curvature must necessarily be very great is apparent from the fact that to include the entire image of the Sun in the focal plane of the forty-inch objective a slit nearly eight inches in length is required, together, of course, with prisms of corresponding height. In the course of the determination of the curvature some results were arrived at which may be of interest as bearing upon the character of the familiar Ditscheiner formula.[1]

In order to secure axes of reference for measurement a series of very fine wires were stretched across the first slit and fastened by means of "Rowland's universal wax." These were represented upon the photographic plate by sharp lines, the relative distances of which could be determined with great accuracy, and which consequently were well adapted to serve as axes of abscissae. For the corresponding axis of ordinates the edge of the exposure produced by the widened second slit was taken. To insure perpendicularity the slits were first set as nearly parallel as possible and a slight correction for slope was applied later to the measures. These last were made upon the aluminium line at λ 3944, K itself being too broad and diffuse, and are accurate to 0.01 mm, the nature of the line and the slightly fuzzy edge of the exposure preventing closer measurement. The distances between the axes of abscissae, however, are accurate to 0.001 mm.

[1] SCHEINER'S *Astronomical Spectroscopy* (Frost), p. 15.

It at once became desirable to compare these measures with the results given by the constants of the instrument, and here it was evident that the approximate character of the Ditscheiner formula would probably debar its use. In order to develop a rigorous expression I had recourse to the method used by Professor Lord for the derivation of the ordinary formula,[1] and, taking the equations obtained by him in the first part of his article, substituted in them rigorous values for the angles involved. The process then consisted merely of solving for the unknown quantity, the sign of the radical being determined by the conditions of the problem. Using Professor Lord's notation the result is

$$\frac{X}{f} = -\sin\left[-\sin^{-1}\left(n\sin\frac{A}{2}\right)+\sin^{-1}\left\{-n\cos A\sin\frac{A}{2}+\sqrt{\sin^2 A\frac{Z^2(n^2-1)}{f'^2-Z^2}+n^2\sin^2\frac{A}{2}(\cos A+1)^2}\right\}\right],$$

in which f and f' denote the focal lengths of the camera and collimator lenses respectively. The prisms are considered to be in the position of minimum deviation.

This is the result for a single prism. For a second prism it is clear that the conditions are different in that we are obliged to consider the curved form of the image emerging from the first prism. The procedure, however, is as before except that the angle of projection of the incident ray upon the principal section of the prism (x) can no longer be considered constant. The result, which is somewhat complicated, is as follows:

$$\frac{X}{f} = -\sin\left[-\sin^{-1}\left(n\sin\frac{A}{2}\right)+\sin^{-1}\left\{-\cos A\sin\left[\sin^{-1}\left(n\sin\frac{A}{2}\right)-(x'-x'_0)\right]+\sqrt{\sin^2 A\frac{Z^2(n^2-1)}{f'^2-Z^2}+2n^2\sin^2\frac{A}{2}(1+\cos A)-\sin^2 A\sin^2\left[\sin^{-1}\left(n\sin\frac{A}{2}\right)-(x'-x'_0)\right]}\right\}\right],$$

where

[1] This JOURNAL, 5, 348, May 1897.

$$x' - x'_0 = -\sin^{-1}\left(n \sin\frac{A}{2}\right) + \sin^{-1}\left\{ -n\cos A \sin\frac{A}{2} + \sqrt{\sin^2 A \frac{Z^2(n^2-1)}{f'^2 - Z^2} + n^2 \sin^2\frac{A}{2}(\cos A + 1)^2}\right\}.$$

With the last formula and the instrumental constants

$$n = 1.64906 \text{ (for K)}\,;\quad A = 60°\,;\quad f = 952^{mm}\,;\quad f' = 956^{mm},$$

the values of the curvature were computed for fourteen lines extending outward from the center of the photographic plate. These values, together with those obtained from the Ditscheiner formula, are gathered in the following table and compared with the measured results. As usual Z denotes distance from the middle of the spectrum, and X the departure of the spectral line from a right line. The unit is the millimeter:

Z	X			Residuals		
	Measured	Rigorous formula	Ditscheiner formula	M.-R.	M.-D.	R.-D.
4.761	0.05	0.050	0.044	±0.00	+0.01	+0.006
12.037	0.29	0.286	0.280	±0.00	+0.01	+0.006
16.825	0.55	0.551	0.548	±0.00	±0.00	+0.003
25.718	1.28	1.277	1.280	±0.00	±0.00	−0.003
30.375	1.78	1.783	1.786	±0.00	−0.01	−0.003
35.711	2.46	2.465	2.468	−0.01	−0.01	−0.003
40.341	3.14	3.143	3.150	±0.00	−0.01	−0.007
49.172	4.68	4.681	4.680	±0.00	±0.00	+0.001
56.724	6.24	6.243	6.228	±0.00	+0.01	+0.015
62.632	7.62	7.622	7.595	±0.00	+0.02	+0.027
71.155	9.86	9.866	9.800	−0.01	+0.06	+0.066
77.890	11.87	11.867	11.744	±0.00	+0.13	+0.123
83.775	13.75	13.755	13.585	±0.00	+0.17	+0.170
88.674	15.45	15.455	15.220	−0.01	+0.23	+0.235

An inspection of these results shows that the parabola of the Ditscheiner formula crosses the curve of the rigorous formula at two points, and that up to the second of these the correspondence of the two is close. The general conclusion may be drawn that for any work except that requiring an exceptionally long slit the ordinary formula is quite sufficient.

YERKES OBSERVATORY,
March 1900.

A SECOND SPECTRUM OF HYDROGEN BEYOND λ 185 μμ.

By VICTOR SCHUMANN.

I SHOWED in 1893[1] that by no means the whole of the radiation of hydrogen was included in the region previously known, which embraced the visible spectrum and the adjacent ultra-violet, but that on the contrary hydrogen develops its principal energy beyond the wave-length 185 μμ. Until recently I knew of only a single spectrum in this region of previously unrecognized refrangibility, and this was the spectrum produced when electric discharges are passed through a Plücker tube filled with hydrogen at moderate pressure. The mode of the discharge, which is well known to have a great effect on the visible spectrum and the adjoining ultra-violet, passed directly over tc the new hydrogen region without any trace of difference, in spite of numerous experiments I made in the attempt to show the contrary. Thus its original condition was maintained even on the introduction into the circuit of a Leyden jar and an air gap, except that a moderate change took place in its energy in general. It was never possible to recognize a disappearance or a broadening of the lines, or their transformation into a continuous spectrum, which the long-known hydrogen spectrum readily displays at a pressure of from a few centimeters upward.

Now I have recently found that the metallic spectra beyond λ 185 μμ, which are still provisionally connected with discharges in hydrogen at atmospheric pressure, exhibit a large number of lines in common. Continued experiments showed that these lines are due to hydrogen. While at the first comparison of these two spectra in this region, one is inclined to regard them as related, on account of their similarity, it is striking that a careful comparison leads to the fact that they are in complete

[1] *Sitzungsberichte* der K. Akad. der Wiss. in Wien. *Mathemat.—Naturwiss. Classe.* 102, Abth. IIa, 415–475, 625–694.

agreement in respect to neither their distribution of energy nor their refrangibility. Deviations can be demonstrated to exist throughout.

In this second spectrum of hydrogen also no tendency to a broadening of the lines is appreciable, in spite of the high pressure and the greater potential of the discharge necessary to its production. This fact deserves the more attention, as we should expect the opposite from the behavior of the rhythmical hydrogen lines, the broadening of which increases with the refrangibility under suitable experimental conditions.

I have not yet succeeded in photographing by itself this spectrum corresponding to atmospheric pressure. At present I recognize it only as an attendant phenomenon of the metallic spectra of this region. The possibility is not excluded that several of its lines are suppressed by the presence of metallic vapors.

Its activity is a function of the wave-length. Its lines are entirely absent, those of the metal alone appearing, when the spark is unusually short. This occurred in my experiments with a separation of the electrodes of from 0.1 to 0.2 mm. But exceptions are found in this respect, as was shown in the spectrum of copper.

In general the hydrogen radiations at atmospheric pressure are decidedly feebler in their action than those of the Plücker tubes. It is therefore questionable whether they can be followed so far into the ultra-violet as those of the tube, to which I was able in 1895 to assign an extensive field of radiation beyond the estimated wave-length 100 $\mu\mu$.

Minor Contributions and Notes

PLANS OF AMERICAN ECLIPSE PARTIES.

THE following circular letter was issued by the Eclipse Committee of the Astronomical and Astrophysical Society of America on March 29, 1900:

DEAR SIR: In response to a circular letter issued by this committee on February 10, 1899, preliminary statements have been received from many astronomers regarding the work which they expect to undertake in connection with the total solar eclipse of May 28, 1900. The committee's expression of a desire for some measure of coöperation met with favorable consideration. The more important suggestions for eclipse observations offered by these astronomers may be found in the preliminary report of the committee, which was published in the ASTROPHYSICAL JOURNAL for October 1899.

With these and other suggestions in mind the committee now begs leave to offer the following remarks:

1. Observations made without a definite purpose, and not based upon a careful consideration of the end to be attained, will rarely be of scientific value. The more important observations which may be undertaken are enumerated in the paragraphs below.

2. *Relative position of the Sun and Moon.*—(This will require the observer's position and the time to be known.) (*a*) From visual observations of contacts, especially contacts II and III, made at stations near the central line, and at stations near the boundaries of the shadow path. (*b*) From photographs of the solar crescent obtained with long-focus instruments at stations on the central line, within one minute of the contacts, the exact moments of exposure being noted. The program of exposures should be symmetrical with reference to the middle of the eclipse. Snap shots of the solar crescent taken a moment before the Sun is entirely covered, and the moment after it reappears, with a large camera, may also be useful if the photographer can give the moments to the nearest second of standard time. The slowest plates should be used, and the exposures given by automatic shutters. With a camera ratio of $\frac{a}{f} = \frac{3}{480}$, an exposure of 0.001 second is abundant. Excessive exposures cannot be expected to yield results comparable to visual observations of the contacts.

3. *Drawings of the corona* (made at the telescope).—Attention should be directed to the structure of the inner corona (especially the regions near large prominences) and to the general outline of the corona. Drawings of details should not attempt to cover large areas.

4. *Color of prominences.*—Compare prominences seen with a telescope and determine relative degree of redness of each. Slight variations in tint may not be important, as from the Purkinje phenomenon the brightest prominences should seem the reddest. White prominences may perhaps be seen. Provision must be made for determining the position angles of the prominences observed.

5. *Photographs of the corona.*—Attention may be called to three classes of camera lenses used for recording the corona. (*a*) Lenses for which $\frac{a}{f}$ is $>$ or $= \frac{1}{6}$, especially adapted to recording the details of the outer corona and the extensions. A wide range of exposures, from $\frac{1}{100}$ second up, should prove useful. The greatest extent of corona hitherto recorded was on triple-coated plates, exposure 20 seconds. Some observers consider that long exposures on very slow plates, fully developed, should be effective in distinguishing the long streamers on the bright-sky background. Some also believe that the faint extensions will be best photographed with lenses for which $\frac{a}{f}$ is considerably less than $\frac{1}{6}$. (*b*) Lenses in which $\frac{a}{f}$ is about $\frac{1}{15}$, especially adapted to recording the details of the mid-corona. The rear lens of a photographic doublet may be used alone to give a long focus. With rapid plates, exposures of $\frac{1}{60}$ second should easily record the prominences, $\frac{1}{10}$ to $\frac{1}{5}$ second the inner corona, and a range of longer exposures the mid-corona. (If equatorial mounting and clock-work are wanting, exposures should not exceed one or two seconds for $f = 60$ inches, and similarly in other cases.) (*c*) Objectives of relatively great focal length, giving details of structure in the inner corona. The objective may be pointed directly at the Sun and used with a moving photographic plate; or it may receive light from a suitable heliostat. With $\frac{a}{f} = 196$, an exposure of $\frac{1}{4}$ second, on slow plates, has recorded the prominences. Revolving diaphragms immediately in front of the photographic plate and concentric with the Moon's image, may be used to reduce the equivalent exposure time of the inner corona.

Before and after the total phase it will be interesting to repeat, and extend as far as possible, the successful experiments made at the Chile and Indian eclipses, of photographing the corona many seconds before and after totality.

In all photographic work care must be taken to provide for the accurate orientation of the coronal image. A satisfactory method consists in exposing a plate to the sky on a dark night, allowing the stars to trail across the plate.

For cameras in which $\frac{a}{f}$ is large, β *Herculis* will give a suitable trail. *Mercury* and ϵ *Tauri* will appear on most photographs of the corona, and will also serve as an excellent means of orientation.

6. *Photographic search for an intra-mercurial planet.*— The lenses recommended for this purpose in Harvard College Observatory *Circular* No. 48 have an aperture of 3 inches and a focal length of 11 feet 4 inches. It is stated in the *Circular* that with such lenses stars as faint as the eighth magnitude can be photographed during the eclipse in an exposure of one minute. Portrait lenses of large aperture and rapid rectilinear lenses may also be used. The sky surrounding the Sun may well be divided among several observers, as few individuals will be provided with enough lenses to cover the whole region. At least two comparable photographs of a given part of the sky should be made by each observer. The length of exposure which can advantageously be employed with each lens must take into account the strength of the bright-sky background; and while the brightness of the sky varies at different eclipses, some idea of the requirements of the problem may be gained by photographing a portion of the evening sky in which a second magnitude star, whose position is known, is just visible.

7. *Distribution of "coronium."*— Observations of the corona with a direct-vision prism in the eyepiece of a field glass, or with an objective prism or grating attached to a telescope used either visually or photographically, should show whether the image corresponding to the green line of this gas has a well-defined structure, or a nearly uniform intensity. The *dispersive power should be strong* in order to reduce the strength of the continuous spectrum background.

8. *Position of the green coronal line.*— The wave-length of the line can best be determined from photographs taken with a powerful prismatic spectrograph. Direct visual observations with a suitable spectroscope and telescope will, however, suffice to show whether the line coincides with the chromospheric line at 1474 *K*. Accurate determinations of the wave-lengths of the bright lines near λ 399 and λ 423 are also desirable.

9. *The spectrum of the "flash"* may be photographed with an objective prism or a spectograph used in conjunction with a telescope. A concave grating spectroscope or an objective grating might also be employed. For this work stations should be selected not far from the northern and southern boundaries of the shadow path. If possible the observations should include a study of the dark line spectrum, before the flash at second contact and after the flash at third contact, and a study of the coronal spectrum.

10. *The heat radiation of the corona* should be measured in the streamers and rifts, and at various distances from the Sun's limb.

11. *Photometric observations of the corona* at various distances from the limb should be made photographically, in view of the brief duration of totality.

12. *Photometric observations of Mercury* during the total phase are recommended by Professor Müller in an article published in the ASTROPHYSICAL JOURNAL for March 1900.

Eclipse photographers cannot be too strongly cautioned against a dense development of the plate. This has been the great fault with most of the negatives at previous eclipses. The image should be slowly developed and kept as thin and transparent as possible.

All photographic plates used in the eclipse problems should be "backed" to prevent halation. Water-color lampblack, reduced to the consistency of paste and applied to the back of the plate, will answer well for this purpose. Or the back of the plate may be flowed with a mixture of normal collodion 100 parts, chrysoïdine 3 parts.

For valuable information regarding probable weather conditions, local time and duration of totality, etc., reference is made to *Weather Bureau Bulletin* No. 209 and the Supplement to the *American Ephemeris* for 1900.

In some of the work outlined above, notably that referred to in paragraphs (3) and (6), it is desirable that there should be coöperation among observers. It is also of great importance that the eclipse stations should be distributed along a considerable length of the path of totality, so that local cloudiness may not affect all parties. For the purpose of securing for general publication accurate information regarding proposed observations, and in the hope of bringing about some degree of coöperation, the Committee requests that replies be sent to the following questions:

1. Do you intend to observe the eclipse?

2. If so, what site do you expect to occupy?

3. If any other location would be equally convenient, kindly state in what region.

4. If possible, kindly name the members of your party.

5. What observations will be made by the members of your party? What instruments will be employed?

6. If your present plans do not prevent, are you willing to coöperate with other parties, especially in undertaking observations such as those named in paragraphs (3) and (6) above?

Please be kind enough to send replies at your earliest convenience to the Secretary of the Committee.

Very respectfully,

SIMON NEWCOMB, *Chairman*
GEORGE E. HALE, *Secretary*
E. E. BARNARD,
W. W. CAMPBELL.
} Eclipse Committee.

From the replies received by the Committee, the following information regarding the plans of eclipse parties has been derived:

NORFOLK, VA. NATIONAL GEOGRAPHIC SOCIETY.

NEAR NORFOLK, VA.

PARTY FROM BROWN UNIVERSITY.

Members.—Winslow Upton, in charge; Frederic Slocum, John Edwards, Howard D. Kenyon, and others.

Principal instruments.—Two 4-inch telescopes, one 2½-inch telescope, several cameras mounted equatorially, combined transit and zenith telescope.

Proposed observations.[1]—(2) (a), (b); (3); (5) (a), (b).

SOUTH OF NORFOLK, VA.

PARTY FROM GEORGETOWN COLLEGE OBSERVATORY.

Members.—J. G. Hagen, in charge; Messrs. Zwack, Brosnan, Hedrick, and others.

Proposed observations.—(3); (5).

NEAR RALEIGH, N. C.

PARTY FROM TRINITY COLLEGE, DURHAM, N. C.

Members.—C. W. Edwards, in charge; W. H. Pegram, two students.

Principal instruments.—Double mirror heliostat, large spectrometer, 3½-inch telescope, cameras, concave grating spectroscope of 10 feet radius.

Proposed observations.—(2); (3); (5); possibly (6).

PINEHURST, N. C.; BARNESVILLE, GA.; GRIFFIN, GA. (near the northern limit of totality.)

PARTIES FROM THE U. S. NAVAL OBSERVATORY.

Members.[2]—S. J. Brown, in charge; (1) Observatory staff: Messrs. A. N. Skinner, T. J. J. See, M. Updegraff, and W. S. Eichelberger; G. A. Hill, T. I. King, and F. B. Littell; W. M. Lawton, Hammond, and G. H. Peters. (2) Associate members: Messrs. J. S. Ames, L. E. Jewell, N. E. Dorsey, Hoff, Reese, and Krouse, of Johns Hopkins University; Messrs. Henry Crew and R. R. Tatnall, of the Northwestern University; H. C. Lord, of Ohio State University; F. L. Chase, of Yale University; J. K. Rees and S. A. Mitchell, of Columbia University; Mr. A. L. Colton, formerly of the Lick Observatory; Mr. Charles A. Post, of Bayport, L. I. Dr. W. J. Humphreys, of the University of Virginia, will also probably occupy a station near the limit of totality in South Carolina, near Winnsboro.

Principal instruments.—Telescopes and cameras ranging from a 40-foot photoheliograph down to one of 4 inches aperture and 8 inches focal length;

[1] The numerals refer to the numbered paragraphs of the above circular.

[2] Definite information as to the assignment of the different observers to the various stations has not been received.

concave gratings of 21 and 10 feet radius; objective gratings, slitless spectroscopes, and large prismatic camera; polariscopes.

Proposed observations.—(2) (a), (b); (3); (5) (a), (b), (c); (7); (8); (9); polarization of the bright line spectrum of the corona; general polarization of the continuous spectrum; velocity, size, and direction of shadow bands.

WADESBORO, N. C.

1. PARTY FROM BRITISH ASTRONOMICAL ASSOCIATION.

Members.— Rev. J. M. Bacon, in charge; seven other members.

Principal instruments.—Photographic telescope of 4.1 inches aperture and 60 inches focal length; telephoto lens; four equatorially mounted cameras; telescopic kinematograph; slitless spectroscope; instrument for recording photographically the brightness of the sky at the zenith.

Proposed observations.—(5) (a), (b); (7); (11); brightness of sky; shadow bands.

2. PARTY FROM PRINCETON UNIVERSITY.

Members.—C. A. Young, in charge; Messrs. Brackett, Magie, Libbey, Reed, McClenahan, Russell, Fisher, and others.

Proposed observations.—(2) (a); (3); (4); (5); (7); (8).

3. PARTY FROM SMITHSONIAN INSTITUTION.

Members.—S. P. Langley, in charge, with about twelve assistants.

Principal instruments.—Two coelostats; large spectro-bolometer with photographic registration; photographic telescopes of 12 inches aperture and 135 feet focal length, 5 inches aperture and 40 feet focal length, 6 inches aperture and 7½ feet focal length, etc.

Proposed observations.—(2) (b); (3); (5) (a), (b), (c); (6); (9); (10); bolographs of the spectrum of the corona.

4. PARTY FROM VASSAR COLLEGE.

Members.—Mary W. Whitney, in charge; Caroline E. Furness, several students.

Principal instruments.—Three 3-inch Clark telescopes.

Proposed observations.—(3).

5. PARTY FROM YERKES OBSERVATORY.

Members.—George E. Hale, in charge; E. E. Barnard, E. B. Frost, F. Ellerman, G. W. Ritchey. Volunteers: A. S. Flint, Washburn Observatory; H. M. Goodwin and A. A. Noyes, Massachusetts Institute of Technology; G. I. Isham, Chicago; and others.

Principal instruments.—Coelostat with two mirrors; photographic telescope of 6 inches aperture and 62 feet focal length; bolometer and 20-inch

concave mirror for measuring the heat radiation of the corona;[1] concave gratings of 10 feet and 5 feet radius; plane gratings; prismatic cameras; several cameras mounted equatorially; Heyde universal instrument; 3-inch equatorial.

Proposed observations.—(2) (a); (5) (a), (b), (c); (6); (7); (9); (10).

NEWBERRY, S. C.

PARTY FROM UNITED STATES WEATHER BUREAU.

Members.—Cleveland Abbe, in charge; Frank H. Bigelow.

Principal instruments.—Four-inch telescope, polariscopes.

Proposed observations.—(3); (5); polarization of the sky.

The Weather Bureau will secure standard meteorological observations from a large number of its regular stations in the southern and southwestern states, special orders being issued for this purpose.

WASHINGTON, GA.

PARTY FROM BLUE HILL METEOROLOGICAL OBSERVATORY AND MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

Members.—A. L. Rotch, in charge; A. E. Burton, of the Massachusetts Institute of Technology, with several students; A. E. Douglass, of Lowell Observatory; assistants from Blue Hill Observatory.

Principal instruments.—Five-inch equatorial; magnetic and meteorological apparatus.

Proposed observations.—(1); (3); shadow bands; eclipse wind; zodiacal light; magnetic observations.

UNION POINT, GA.

PARTY FROM CHABOT OBSERVATORY.

Members.—Charles Burckhalter, in charge; seven assistants.

Principal instruments.—Two 4-inch telescopes of 15 feet focal length, with device for giving suitable exposure for all parts of the corona.

Proposed observations.—(5) (b), (c).

FORSYTHE, GA.

PARTY FROM RENSSELAER POLYTECHNIC INSTITUTE.

Members.—C. W. Crockett, in charge.

Principal instrument.—Three and one half-inch equatorial.

Proposed observations.—(3).

[1] Through the courtesy of Professor Langley this apparatus will be used in conjunction with one of the coelostats of the Smithsonian party.

THOMASTON, GA.

PARTY FROM LICK OBSERVATORY.

Members.—W. W. Campbell, in charge; C. D. Perrine, and others.

Principal instruments.—Photographic telescope of 5 inches aperture and 40 feet focal length, for recording prominences and inner corona; photographic telescope of 5 inches aperture and 6½ feet focal length; Dallmeyer 6-inch camera; Willard 5½-inch portrait lens, and other cameras; slit spectrograph with three prisms; spectrograph with objective grating; spectrograph with two objective prisms; photometric apparatus, visual telescope, etc.

Proposed observations.—(2)(a); (5)(a) and (5)(b); (6); (7); (8); (9); (11).

GREENVILLE, ALA.

PARTY FROM HARVARD COLLEGE OBSERVATORY.

Members.—W. H. Pickering, in charge; W. H. Attwill, J. R. Edmands.

Principal instruments.—Cameras from 0.04 inches to 6 inches aperture, and from 1 inch to 11 feet 4 inches focal length; 4-inch and 5-inch telescopes.

Proposed observations.—(3); (5); (6); (11).

FORT DEPOSIT, ALA.

PARTY FROM ALLEGHENY OBSERVATORY.

Members.—F. L. O. Wadsworth, in charge; J. A. Brashear, and others.

Principal instruments.—Two 4-inch cameras; one 4½-inch camera, and another 3-inch, both for curved plates; a 9½-inch reflector of 38 inches focus; a 20-inch reflector of 100 feet focus, besides smaller camera lenses. Spectroscopic apparatus will consist of three large glass prisms of 3-inch by 4½-inch face, and numerous gratings.

Proposed observations.—(5)(a), (b), (c); (6); (7); (8); (9).

INDIVIDUAL OBSERVERS.

MEXICO (near M. C. R. R.).

Miss Rose O'Halloran.

Principal instruments.—Four-inch refractor of 60 inches focus; 2½-inch portrait lens.

Proposed observations.—(5)(b); (3).

NEAR NORFOLK, VA.

John N. Stockwell.

Principal instruments.—Field glass and appliance for measuring angles.

Proposed observations—General visual observations.

A PHOTOGRAPHIC SEARCH FOR AN INTERMERCURIAL PLANET.[1]

IT has not been, in general, the policy of the Harvard College Observatory to send expeditions to observe total eclipses of the Sun. First, since in case of cloudy weather, no return is obtained for the expenditure of a sum of money which is often large. Secondly, if clear, the results in many cases are only a series of pictures of the corona and protuberances which add but little to our knowledge of them. Therefore, when officers of this Observatory have observed eclipses, it has generally been largely at their own expense. When, however, a new problem presents itself, some aid is rendered from the funds of the Observatory, in the construction of instruments and for similar expenses. The following plan for observing the Eclipse of May 28, 1900, has been prepared by Professor W. H. Pickering:

It is a fact capable of demonstration that the faintness of a star that may be photographed with a given instrument, against a bright background of sky, depends, within certain limits, directly on the length of the focus of the lens, and is independent of its aperture.

In the *Harvard Observatory Annals*, **18**, 104, it was shown, if the place in which to look for the pole star is known, that three minutes after it first becomes visible to the naked eye in the evening, the light of the sky in its immediate vicinity is of about the same photographic intensity as that of the sky surrounding the Sun at the time of a total solar eclipse.

Starting with these two fundamental facts, a series of experiments has been undertaken with a photographic lens having an aperture of 3 inches, and a focal length of 11 feet 4 inches. The curves adopted were those employed in an ordinary landscape lens, and it was found that the field was large enough to cover nine 8×10 photographic plates arranged in three rows of three each. This result was only obtained, however, by attaching the plates to the interior of a concave surface of double curvature, and thus obtaining a curved field.

By giving an exposure of one minute in the region of the pole, with this instrument, three minutes after the pole star first became visible, it was found that the light of the sky was sufficient to darken the plate appreciably, but not so much as to prevent stars of the eighth magnitude appearing with sufficient intensity to be found by a careful search, in the larger part of the field of view.

Three similar lenses have now been ordered, and the four will be placed upon one mounting, in such a manner as to photograph a region extending

[1] *Harvard College Observatory Circular* No. 48.

for sixteen degrees on either side of the Sun, and having a breadth of ten degrees throughout its length. Throughout nineteen degrees of its length every portion of the region will appear upon two separate plates.

The satellites of *Mars*, *Jupiter*, and *Saturn* all revolve very nearly in the equatorial planes of their primaries, and in the same manner *Mercury* revolves very nearly in the equatorial plane of the Sun, which is inclined about seven degrees to the plane of the ecliptic. It is therefore reasonable to suppose that bodies still nearer to the Sun would revolve in the same plane. It so happens that the Earth passes through this plane about one week after the date of the solar eclipse of next May, so that there is a strong probability that if an intermercurial planet exists, it will appear somewhere upon the narrow line forming the projection of this plane upon the celestial sphere. It will be seen, therefore, that the date of this eclipse is especially favorable for the proposed search.

We have very good evidence, from the visual observations hitherto made, that no intermercurial planet brighter than the third or fourth magnitude exists. We possess no evidence whatever for or against the existence of fainter bodies in this region having sufficient size to be properly called planets. We are reasonably certain that the immediate vicinity of the Sun is filled with countless bodies of such size as to be properly described as meteors.

If we assume that at its average brightness, *Mercury* is of the first magnitude, and that the albedo of an intermercurial planet is the same as that of *Mercury*, we shall find that at the distance of *Mercury* from the Sun, a body of the eighth magnitude would be 120 miles in diameter. If its distance from the Sun was but one half as great, its diameter would be 60 miles, and if but one quarter as great, or nine million miles, it would be 30 miles in diameter. Judging by the analogous case of *Jupiter*, the existence of such a small planet is quite possible.

Should such a body exist, and should it appear upon the plates, which it is proposed to expose somewhere in the State of Alabama, we should still be entirely at a loss to compute the orbit, or to determine the distance of the body from the Sun. If, however, other photographs of it should be obtained with a similar apparatus, in Spain or Algeria, we should then be enabled to compute an approximate orbit, based on the assumption that it moved in a circular path. It might then be found again at the following eclipse, which occurs a year later, and a more accurate elliptical orbit could be computed for it. While it is desirable that the duplicate apparatus should also be furnished with four lenses, this is not necessary, and in case the planet should be found upon our plates, two lenses, one photographing the region on each side of the Sun, would be all that would be necessary to independently make the discovery, and furnish the elements necessary to compute the circular

orbit. It is in the hope of inducing some European observer to supply himself with this apparatus, that the present article has been written.

The foregoing plan appears to be of sufficient importance to justify aid from the Observatory. Preparations have, therefore, been made to give it a careful trial. It is hoped that this early publication may permit similar observations to be made at a second station sufficiently distant to reduce the danger of failure from clouds, and if an intermercurial planet should be found, to furnish an approximate determination of the form of its orbit.

EDWARD C. PICKERING.

February 13, 1900.

THE TRIFID NEBULA IN SAGITTARIUS.
Photographed with the Crossley Reflector of the Lick Observatory